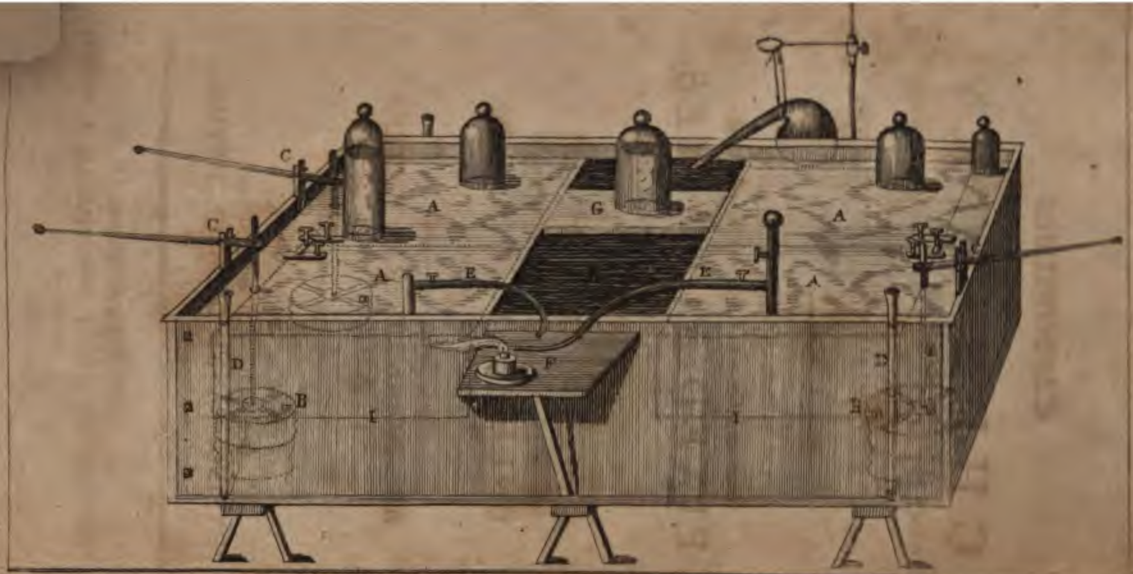

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Conversations
ON
CHEMISTRY,
In which the Elements of that Science are familiarly explained and illustrated
BY EXPERIMENTS AND PLATES.

TO WHICH ARE ADDED,
Some late Discoveries on the subject of the
FIXED ALKALIES,
BY H. DAVY, ESQ.
Of the Royal Society.

A Description and Plate of the
PNEUMATIC CISTERN
Of Yale College.—
AND,
A short Account of
ARTIFICIAL MINERAL WATERS
In the United States.

With an APPENDIX,
Consisting of TREATISES on
DYEING, TANNING AND CURRYING.

From Sidney's Press.
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1809.

Aug. Van Schaick

PREFACE.

IN venturing to offer to the public, and more particularly to the female sex, an Introduction to Chemistry, the author, herself a woman, conceives that some explanation may be required; and she feels it the more necessary to apologize for the present undertaking, as her knowledge of the subject is but recent, and as she can have no real claims to the title of chemist.

On attending for the first time, experimental lectures, the author found it almost impossible to derive any clear or satisfactory information from the rapid demonstrations which are usually, and perhaps necessarily crowded into popular courses of this kind. But frequent opportunities having afterwards occurred of conversing with a friend on the subject of chemistry, and of repeating a variety of experiments, she became better acquainted with the principles of that science, and began to feel highly interested in its pursuit. It was then that she perceived, in attending the excellent lectures delivered at the Royal Institution, by the present Professor of Chemistry, the great advantage which her previous knowledge of the subject, slight as it was, gave her over others who had not enjoyed the same means of private instruction. Every fact or experiment, attracted her attention, and served to explain some theory to which she was not a total stranger; and she had the gratification to find that the numerous and elegant illustrations, for which that school is so much distinguised, seldom failed to produce on her mind the effect for which they were intended.

Hence it was natural to infer, that familiar conversation was, in studies of this kind, a most useful auxiliary source of information; and more especially to the female sex, whose education is seldom calculated to prepare their minds for abstract ideas, or scientific language.

As, however, there are but few women who have access to this mode of instruction; and as the author was not acquainted with any book that could prove a substitute for it, she thought that it might be useful for beginners, as well as satisfactory to herself, to trace the steps by which she had acquired her little stock of chemical knowledge, and to record in the form of dialogue, those ideas which she had first derived from conversation.

But to do this with sufficient method, and to fix upon a mode of arrangement, was an object of some difficulty. After much hesitation, and a degree of embarrassment, which, probably, the most competent chemical writers have often felt in common with the most superficial, a mode of division was adopted, which, though the most natural, does not always admit of

being strictly pursued—it is that of treating first of the simplest bodies, and then gradually rising to the most intricate compounds.

It is not the author's intention to enter into a minute vindication of this plan. But, whatever may be its advantages or inconveniences, the method adopted in this work is such, that a young pupil, who should occasionally recur to it, with a view to procure information on particular subjects, might often find it obscure or unintelligible; for its various parts are so connected with each other as to form an uninterrupted chain of facts and reasonings, which will appear sufficiently clear and consistent to those only who may have patience to go through the whole work, or have previously devoted some attention to the subject.

It will, no doubt, be observed, that in the course of these conversations, remarks are often introduced, which appear much too acute for the young pupils, by whom they are supposed to be made. Of this fault the author is fully aware. But in order to avoid it, it would have been necessary either to omit a variety of useful illustrations, or to submit to such minute explanations and frequent repetitions, as would have rendered the work much less suited to its purpose.

In writing these pages, the author was more than once checked in her progress by the apprehension, that such an attempt might be considered by some, either as unsuited to the ordinary pursuits of her sex, or ill justified by her own recent and imperfect knowledge of the subject. But, on the one hand, she felt encouraged by the establishment of those public institutions, open to both sexes, for the dissemination of philosophical knowledge, which clearly prove, that the general opinion no longer excludes women from an acquaintance with the elements of science; and, on the other, she flattered herself, that whilst the impressions made upon her mind, by the wonders of Nature studied in this new point of view, were still fresh and strong, she might perhaps succeed the better in communicating to others the sentiments she herself experienced.

It will be observed, that, from the beginning of the work it is taken for granted, that the reader has previously acquired some slight knowledge of natural philosophy, a circumstance, indeed, which appears very desirable. The author's original intention was to commence this work by a small tract, explaining, on a plan analogous to this, the most essential rudiments of that science. This idea she has since abandoned; but the manuscript was ready, and might perhaps have been printed at some future period, had not an elementary work of a similar description, under the title of "Scientific Dialogues," been lately pointed out to her, which, on a rapid perusal, she thought very ingenious, and well calculated to answer its intended object.

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Gerard Van Schaick

CONVERSATIONS

ON

CHEMISTRY.

ON SIMPLE BODIES.

Conversation I.

On the General Principles of Chemistry.

Mrs. B.

AVING now acquired some elementary notions of URAL PHILOSOPHY, I am going to propose to you ier branch of science to which I am particularly ous that you should devote a share of your atten- This is CHEMISTRY, which is so closely con- ed with Natural Philosophy, that the study of the nust be incomplete without some knowledge of other; for it is obvious that we can derive but a imperfect idea of bodies from the study of the ral laws by which they are governed, if we remain y ignorant of their intimate nature.

roline. To confess the truth, Mrs. B. I am not sed to form a very favourable idea of Chemistry, lo I expect to derive much entertainment from I prefer those sciences that exhibit nature on a d scale, to those which are confined to the mi- e of petty details. Can the studies which we have

lately pursued, the general properties of matter, or the revolutions of the heavenly bodies, be compared to the mixing up of a few insignificant drugs?

Mrs. B. I rather imagine that your want of taste for chemistry proceeds from the very limited idea you entertain of its object. You confine the chemist's laboratory to the narrow precincts of the apothecary's shop, whilst it is subservient to an immense variety of other useful purposes. Besides, my dear, chemistry is by no means confined to works of art. Nature also has her laboratory, which is the universe, and there she is incessantly employed in chemical operations. You are surprised, Caroline; but I assure you that the most wonderful and the most interesting phenomena of nature are almost all of them produced by chemical powers. Without entering therefore into the minute details of practical chemistry, a woman may obtain such a knowledge of the science, as will not only throw an interest on the common occurrences of life, but will enlarge the sphere of her ideas, and render the contemplation of Nature a source of delightful instruction.

Caroline. If this is the case, I have certainly been much mistaken in the notion I had formed of chemistry. I own that I thought it was chiefly confined to the knowledge and preparation of medicines.

Mrs. B. That is only a branch of chemistry, which is called Pharmacy; and though the study of it is certainly of great importance to the world at large, it properly belongs to professional men, and is therefore the last that I should advise you to study.

Emily. But did not the chemists formerly employ themselves in search of the Philosopher's Stone, or the secret of making gold?

Mrs. B. These were a particular set of misguided philosophers, who dignified themselves with the name of Alchymists, to distinguish their pursuits from those of the common chemists, whose studies were confined to the knowledge of medicines.

But, since that period, chemistry has undergone so complete a revolution, that, from an obscure and mys-

terious art, it is now become a regular and beautiful science, to which art is entirely subservient. It is true, however, that we are indebted to the alchymists for many very useful discoveries, which sprung from their fruitless attempts to make gold, and which undoubtedly have proved of infinitely greater advantage to mankind than all their chimerical pursuits.

The modern chemists, far from directing their ambition to the imitation of one of the least useful productions of inanimate nature, aim at copying almost all her operations, and sometimes even form combinations, the model of which is not to be found in her own productions. They have little reason to regret their inability to make gold (which is often but a false representation of riches), whilst by their innumerable inventions and discoveries, they have so greatly stimulated industry and facilitated labour, as prodigiously to increase the luxuries as well as the necessaries of life.

Emily. But I do not understand by what means chemistry can facilitate labour; is not that rather the province of the mechanic?

Mrs. B. There are many ways by which labour may be rendered more easy, independently of mechanics; but even the machine the most wonderful in its effects, the steam engine, cannot be understood without the assistance of chemistry. In agriculture, a chemical knowledge of the nature of soils, and of vegetation, is highly useful; and in those arts which relate to the comforts and conveniencies of life, it would be endless to enumerate the advantages which result from the study of this science.

Caroline. But, pray, tell us more precisely in what manner the discoveries of chemists have proved so beneficial to society.

Mrs. B. That would be an unfair anticipation; for you would not comprehend the nature of such discoveries and useful applications, so well as you will do hereafter. Without a due regard to method, we cannot expect to make any progress in chemistry. I wish to direct your observation chiefly to the chemical operations of Nature; but those of Art are certainly of too

high importance to pass unnoticed. We shall therefore allow them also some share of our attention.

Emily. Well then, let us now set to work regularly, I am very anxious to begin.

Mrs. B. The object of chemistry is to obtain a knowledge of the intimate nature of bodies and of their mutual action on each other. You find therefore, Caroline, that this is no narrow or confined science, which comprehends every thing material within our sphere.

Caroline. On the contrary, it must be inexhaustible; and I am at a loss to conceive how any proficiency can be made in a science whose objects are so numerous.

Mrs. B. If every individual substance was formed of different materials, the study of chemistry would indeed be endless; but you must observe, that the various bodies in nature are composed of certain elementary principles, which are not very numerous.

Caroline. Yes; I know that all bodies are composed of fire, air, earth, and water; I learnt that many years ago.

Mrs. B. But you must now endeavour to forget it. I have already informed you what a great change chemistry has undergone since it has become a regular science. Within these thirty years especially, it has experienced an entire revolution, and it is now proved that neither fire, air, earth, nor water, can be called elementary bodies. For an elementary body is one that cannot be decomposed, that is to say, separated into other substances; and fire, air, earth, and water, are all of them susceptible of decomposition.

Emily. I thought that decomposing a body was dividing it into its minutest parts. And if so, I do not understand why an elementary substance is not capable of being decomposed, as well as any other.

Mrs. B. You have misconceived the idea of *Decomposition*; it is very different from mere *division*: the latter simply reduces a body into parts, but the former separates it into the various ingredients, or materials, of which it is composed. If we were to take a loaf of bread, and separate the several ingredients of which it is made, the flour, the yeast, the salt, and the

water, it would be very different from cutting the loaf into pieces, or crumbling it into atoms.

Emily. I understand you now very well. To decompose a body is to separate from each other the various elementary substances of which it consists.

Caroline. But flour, water, and the other materials of bread, according to your definition, are not elementary substances?

Mrs. B. No my dear; I mentioned bread rather as a familiar comparison, to illustrate the idea, than as an example.

The elementary substances of which a body is composed, are called the *constituent* parts of that body; in decomposing it, therefore, we separate its constituent parts. If, on the contrary, we divide a body by chopping it to pieces, or even by grinding or pounding it to the finest powder, each of these small particles will still consist of a portion of the several constituent parts of the whole body: these we call the *integrant* parts; do you understand the difference?

Emily. Yes, I think, perfectly. We *decompose* a body into its *constituent* parts; and *divide* it into its *integrant* parts.

Mrs. B. Exactly so. If therefore a body consists of only one kind of substance, though we may divide it into its integrant parts, it is not possible to decompose it. Such bodies are therefore called *simple* or *elementary*, as they are the elements of which all other bodies are composed. *Compound bodies* are such as consist of more than one of these elementary principles.

Caroline. But do not fire, air, earth, and water, consist, each of them, but of one kind of substance?

Mrs. B. No, my dear; they are every one of them susceptible of being separated into various simple bodies. Instead of four, chemists now reckon upwards of forty elementary substances. These we shall first examine separately, and afterwards consider in their combinations with each other.

Their names are as follow :

LIGHT,	SILEX,	ZINC,
CALORIC,	ALUMINE,	BISMUTH,
OXYGEN,	YTTRIA,	ANTIMONY,
NITROGEN,	GLUCINA,	ARSENIC,
HYDROGEN,	ZIRCONIA,	COBALT,
SULPHUR,	AGUSTINA,	MANGANESE,
PHOSPHORUS,	(25 *Metals.*)	TUNGSTEN,
CARBONE,	GOLD,	MOLYBDENUM,
(2 *Alkalies.*)	PLATINA,	URANIUM,
POTASH,	SILVER,	TELLURIUM,
SODA,	MERCURY,	TITANIUM,
(10 *Earths.*)	COPPER,	CHROME,
LIME,	IRON,	OSMIUM,
MAGNESIA,	TIN,	IRIDIUM,
STRONTITES,	LEAD,	PALLADIUM,
BARYTES,	NICKEL,	RHODIUM.

Caroline. This is, indeed, a formidable list!

Mrs. B. Not so much as you imagine ; many of the names you are already acquainted with, and the others will soon become familiar to you. But, before we proceed farther, it will be necessary to give you some idea of chemical attraction, a power on which the whole science depends.

Chemical Attraction, or the *Attraction of Composition*, consists in the peculiar tendency which bodies of a different nature have to unite with each other. It is by this force that all the compositions, and decompositions, are effected.

Emily. What is the difference between chemical attraction, and the attraction of cohesion, or of aggregation, which you often mentioned to us in former conversations ?

Mrs. B. The attraction of cohesion exists only between particles of the *same* nature, whether simple or compound ; thus it unites the particles of a piece of metal which is a simple substance, and likewise the particles of a loaf of bread which is a compound. The attraction of composition, on the contrary, unites and maintains in a state of combination particles of a *dissimilar* nature ; it is this power that forms each of the

compound particles of which bread consists; and it is by the attraction of cohesion that all these particles are connected into a single mass.

Emily. The attraction of cohesion, then, is the power which unites the integrant particles of a body; the attraction of composition that which combines the constituent particles. Is it not so ?

Mrs. B. Precisely: and observe that the attraction of cohesion unites particles of a similar nature, without changing their original properties; the result of such an union, therefore, is a body of the same kind as the particles of which it is formed; whilst the attraction of composition, by combining particles of a dissimilar nature, produces new bodies, quite different from any of their constituent particles. If, for instance, I pour on the piece of copper, contained in this glass, some of this liquid (which is called nitric acid) for which it has a strong attraction, every particle of the copper will combine with a particle of acid, and together they will form a new body, totally different from either the copper or the acid.

Do you observe the internal commotion that already begins to take place? It is produced by the combination of these two substances; and yet the acid has in this case to overcome, not only the resistance which the strong cohesion of the particles of copper oppose to its combination with them, but also the weight of the copper which makes it sink to the bottom of the glass, and prevents the acid from having such free access to it as it would if the metal were suspended in the liquid.

Emily. The acid seems, however, to overcome both these obstacles without difficulty, and appears to be very rapidly dissolving the copper.

Mrs. B. By this means it reduces the copper into more minute parts, than could possibly be done by any mechanical power. But as the acid can act only on the surface of the metal, it will be some time before the union of these two bodies will be compleated.

You may, however, already see how totally different this compound is from either of its ingredients. It is neither *colourless* like the acid, nor hard, heavy, and

yellow, like the copper. If you tasted it, you would no longer perceive the sourness of the acid. It has at present the appearance of a blue liquid ; but when the union is completed, and the water with which the acid is diluted is evaporated, it will assume the form of regular chrystals, of a fine blue colour, and perfectly transparent. Of these I can shew you a specimen, as I have prepared some for that purpose.

Caroline. How very beautiful they are, in colour, form and transparency ?

Emily. Nothing can be more striking than this example of chemical attraction.

Mrs. B. The term *attraction* has been lately introduced into chemistry as a substitute for the word *affinity*, to which some chemists have objected, because it originated in the vague notion that chemical combinations depend upon a certain resemblance, or relationship, between particles that are disposed to unite ; and this idea is not only imperfect, but erroneous, as it is generally particles of the most dissimilar nature, that have the greatest tendency to combine.

Caroline. Besides, there seems to be no advantage in using a variety of terms to express the same meaning ; on the contrary it creates confusion : and as we are well acquainted with the term attraction in natural philosophy, we had better adopt it in chemistry likewise.

Mrs. B. If you have a clear idea of the meaning, I shall leave you at liberty to express it in the terms you prefer. For myself, I confess that I think the word attraction best suited to the general law that unites the integrant particles of bodies ; and affinity better adapted to that which combines the constituent particles, as it may convey an idea of the preference which some bodies have for others, which the term *attraction of composition* does not so well express.

Emily. So I think ; for though that preference may not result from any relationship or similitude, between the particles (as you say was once supposed), yet, as it really exists, it ought to be expressed.

Mrs. B. Well, let it be agreed that you may use

the terms *affinity*, *chemical attraction*, and *attraction of composition*, indifferently, provided you recollect that they have all the same meaning.

Emily. I do not conceive how bodies can be decomposed by chemical attraction. That this power should be the means of composing them, is very obvious; but how it can at the same time produce exactly the contrary effect, appears to me very singular.

Mrs. B. To decompose a body, is, you know to separate its constituent parts, which, as we have just observed, can never be done by mechanical means.

Emily. No; because mechanical means separate only the integrant particles; they act merely against the attraction of cohesion.

Mrs. B. The decomposition of a body, therefore, can only be performed by chemical powers. If you present to a body composed only of two principles, a third, which has a greater affinity for one of them than the two first have for each other, it will be decomposed, that is, its two principles will be separated by means of the third body. Let us call two ingredients, of which a body is composed, A and B. If we present to it another ingredient C, which has a greater affinity for B, than that which unites A and B, it necessarily follows that B will quit A to combine with C. The new ingredient, therefore, has effected a decomposition of the original body A B; A, has been left alone, and a new compound, B C, has been formed.

Emily. We might, I think, use the comparison of two friends, who were very happy in each other's society, till a third disunited them by the preference which one of them gave to the new-comer.

Mrs. B. Very well, I shall now show you how this takes place in chemistry.

Let us suppose that we wish to decompose the compound we have just formed by the combination of the two ingredients, copper and nitric acid: we may do this by presenting to it a piece of iron, for which the acid has a stronger attraction than for copper; the acid will consequently quit the copper to combine with the iron, and the copper will be what the chemists call

precipitated, that is to say, it will return to its separate state, and reappear in its simple form.

In order to produce this effect, I shall dip the blade of this knife into the fluid, and, when I take it out, you will observe that instead of being wetted with a blueish liquid like that contained in the glass, it will be covered with a very thin pellicle of copper.

Caroline. So it is, really! But then is it not the copper instead of the acid, that has combined with the iron blade!

Mrs. B. No; you are deceived by appearances: it is the acid which combines with the iron, and in so doing deposites the copper on the surface of the blade.

Emily. But cannot three or more substances combine together, without any of them being precipitated?

Mrs. B. That is sometimes the case; but in general, the stronger affinity destroys the weaker; and it seldom happens that the attraction of several substances for each other is so equally balanced as to produce such complicated compounds.

It is now time to conclude our conversation for this morning. But before we part, I must recommend you to fix in your memory the names of the simple bodies, against our next interview.

Conversation II.

On Light and Heat.

Caroline.

WE have learned by heart the names of all the simple bodies, which you have enumerated, and we are now ready to enter on the examination of each of them successively. You will begin I suppose with LIGHT?

Mrs. B. That will not detain us long: the nature of

light, independent of heat, is so imperfectly known, that we have little more than conjectures respecting it.

Emily. But is it possible to separate light from heat; I thought that they were only different degrees of the same thing?

Mrs. B. They are certainly very intimately connected; yet it appears they are distinct substances, as they can, under certain circumstances, be in a great measure separated; the most striking instance of this was pointed out by Dr. Herschel.

This philosopher discovered that heat was less refrangible than light; for in separating the different coloured rays of light by a prism (as we did some time ago), he found that the greatest heat was beyond the spectrum, at a little distance from the red rays, which you may recollect are the least refrangible.

Emily. I should like to try that experiment.

Mrs. B It is by no means an easy one: the heat of a ray of light, refracted by a prism, is so small that it requires a very delicate thermometer to distinguish the difference of the degree of heat within and without the spectrum. For in this experiment the heat is not totally separated from the light, each coloured ray retaining a certain portion of it, though the greatest part is not sufficiently refracted to fall within the spectrum.

Emily. I suppose, then, that those coloured rays which are the least refrangible, retain the greatest quantity of heat?

Mrs. B. They do so.

Caroline. Perhaps the different degrees of heat which the seven rays possess, may in some unknown manner occasion their variety of colour. I have heard that melted metals change colour according to the different degrees of heat to which they are exposed; might not the colours of the spectrum be produced by a cause of the same kind? Do let us try if we cannot ascertain this, Mrs. B? I should like extremely to make some discovery in chemistry.

Mrs. B. Had we not better learn first what is already known? Surely you cannot seriously imagine that, be-

fore you have acquired a single clear idea on chemistry, you can have any chance of discovering secrets that have eluded the penetration of those who have spent their whole lives in the study of that science.

Caroline. Not much, to be sure, in the regular course of events ; but a lucky chance sometimes happens. Did not a child lead the way to the discovery of telescopes ?

Mrs. B. There are certainly a few instances of this kind. But believe me, it is infinitely wiser to follow up a pursuit regularly, than to trust to chance for your success.

Emily. But to return to our subject. Though I no longer doubt that light and heat can be separated, Dr. Herschel's experiment does not appear to me to afford sufficient proof that they are essentially different; for light, which you call a simple body, may likewise be divided into the various coloured rays ; is it not therefore possible that heat may only be a modification of light ?

Mrs. B. That is a supposition which, in the present state of natural philosophy, can neither be positively affirmed nor denied : it is generally thought that light and heat are connected with each other as cause and effect, but which is the cause, and which the effect, it is extremely difficult to determine. But it would be useless to detain you any longer on this intricate subject. Let us now pass on to that of HEAT, with which we are much better acquainted.

Caroline. Heat is not, I believe, amongst the number of the simple bodies ?

Mrs. B. Yes, it is ; but under another name—that of CALORIC, which is nothing more than the principle, or matter of heat.—We suppose caloric to be a very subtile fluid, originally derived from the sun, and composed of very minute particles, constantly in agitation, and moving in a manner similar to light, as long as they meet with no obstacle. But when these rays come in contact with the earth, and the various bodies belonging to it, part of them are reflected from their surfaces according to certain laws, and part enters into them.

Caroline. These rays of heat, or caloric, proceeding from the same source, and following the same direction, as the rays of light, bear a very strong resemblance to them.

Mrs. B. So much so that it often requires great attention not to confound them.

Emily. I think there is no danger of that, if we recollect one great distinction—light is visible, and caloric is not.

Mrs. B. Very right. *Light* affects the sense of *Sight* ; *Caloric* that of *Feeling* : the one produces *Vision*, the other the peculiar sensation of *Heat*.

Caloric is found to exist in a variety of forms, and to be susceptible of certain modifications, all of which may be comprehended under the four following heads :

1. FREE CALORIC.
2. SPECIFIC HEAT.
3. LATENT HEAT.
4. CHEMICAL HEAT.

The first, or FREE CALORIC, is also called HEAT OF TEMPERATURE ; it comprehends all heat which is perceptible to the senses, and affects the thermometer.

Emily. You mean such as the heat of the sun, of fire, of candles, of stoves ; in short of every thing that burns ?

Mrs. B. And likewise of things that do not burn, as for instance, the warmth of the body ; in a word, all heat that is *sensible*, whatever may be its degree, or the source from which it is derived.

Caroline. What then are the other modifications of caloric ? It must be a strange kind of heat that cannot be perceived by our senses ?

Mrs. B. None of the modifications of caloric should properly be called *heat* ; for heat, strictly speaking, is the sensation, produced by caloric, on animated bodies, and this word therefore should be confined to express the sensation. But custom has adapted it likewise to inanimate matter, and we say *the heat of an oven*, *the heat of the sun*, without any reference to the sensation which they are capable of exciting.

It was in order to avoid the confusion which arose from thus confounding the cause and effect, that modern chemists adopted the new word *Caloric*, to express the principle which produces heat; but they do not yet limit the word *heat* (as they should do) to the expression of the sensation, since they still retain the habit of connecting this word with the three other modifications of caloric.

Caroline. But you have not yet explained to us what these other modifications of caloric are.

Mrs. B. Because you are not yet acquainted with the properties of free caloric, and you know we have agreed to proceed with regularity.

One of the most remarkable properties of free caloric is its power of *dilating* bodies. This fluid is so extremely subtile, that it enters and pervades all bodies whatever, forces itself between their particles, and not only separates them, but, by its repulsive power, drives them asunder, frequently to a considerable distance from each other. It is thus that caloric dilates or expands a body so as to make it occupy a greater space than it did before.

Emily. The effect of caloric on bodies therefore, is directly contrary to that of the attraction of cohesion; the one draws the particles together, the other drives them asunder.

Mrs. B. Precisely. There is a kind of continual warfare between the attraction of aggregation and the repulsive power of caloric; and from the action of these two opposite forces, result all the various forms of matter, or degrees of consistence, from the solid, to the liquid and aeriform state. And accordingly, we find that most bodies are capable of passing from one of these forms to the other, merely in consequence of their receiving different quantities of caloric.

Caroline. This is very curious; but I think I understand the reason of it. If a great quantity of caloric is added to a solid body, it introduces itself between the particles in such a manner as to overcome in a considerable degree, the attraction of cohesion; and the body from a solid, is then converted into a fluid.

Mrs. B. This is the case whenever a body is melted; but if you add caloric to a liquid, can you tell me what is the consequence?

Caroline. The caloric forces itself in greater abundance between the particles of the fluid, and drives them to such a distance from each other, that their attraction of aggregation is wholly destroyed; the liquid is then transformed into vapour.

Mrs. B. Very well; and this is precisely the case with boiling water, when it is converted into steam or vapour.

But each of these various states, solid, liquid, and aeriform, admit of many different degrees of density, or consistence, still arising (partly at least) from the different quantities of caloric the bodies contain. Solids are of various degrees of density, from that of gold, to that of a thin jelly. Liquids, from the consistence of melted glue, or melted metals, to that of ether, which is the lightest of all liquids. The different elastic fluids (with which you are not acquainted) admit of no less variety in their degrees of density.

Emily. But does not every individual body also admit of different degrees of consistence, without changing its state?

Mrs. B. Undoubtedly; and this I can immediately show you by a very simple experiment. This piece of iron now exactly fits the frame or ring, made to receive it, but if heated red hot, it will no longer do so, for its dimensions will be so much increased by the caloric that has penetrated into it, that it will be much too large for the frame.

The iron is now red hot; by applying it to the frame, we shall see how much it is dilated.

Emily. Considerably so indeed! I knew that heat had this effect on bodies, but I did not imagine that it could be made so conspicuous.

Mrs. B. By means of this instrument (called a Pyrometer) we may estimate, in the most exact manner, the various dilatations of any solid body by heat. The body we are now going to submit to trial is this small

iron bar ; I fix it to this apparatus, (*Plate* I. *Fig.* 1.) and then heat it by lighting the three lamps beneath it; when the bar dilates, it increases in length as well as thickness ; and, as one end communicates with this wheel-work, whilst the other end is fixed and immoveable, no sooner does it begin to dilate than it presses against the wheel-work, and sets in motion the index, which points out the degrees of dilation on the dial-plate.

Emily. This is indeed a very curious instrument; but I do not understand the use of the wheels : would it not be more simple, and answer the purpose equally well, if the bar pressed against the index, and put it in motion without the intervention of the wheels ?

Mrs. B. The use of the wheels is merely to multiply the motion, and therefore render the effect of the caloric more obvious : for if the index moved no more than the bar increased in length, its motion would scarcely be perceptible : but by means of the wheels it moves in a much greater proportion, which therefore renders the variations much more conspicuous.

By submitting different bodies to the test of the pyrometer, it is found that they are far from dilating in the same proportion. Different metals expand in different degrees, and other kinds of solid bodies vary still more in this respect. But this different susceptibility of dilatation is still more remarkable in fluids than in solid bodies, as I shall show you. I have here two glass tubes, terminated at one end by large bulbs. We shall fill the bulbs, the one with spirit of wine, the other with water. I have coloured both liquids, that the effect may be more conspicuous. The spirit of wine, you see, dilates merely by the warmth of my hand as as I hold the bulb.

Emily. It certainly dilates, for I see it is rising into

PLATE I.

Fig. 1. A A. Bar of metal. 1 2 3. Lamps burning. B B. Wheel work. C. Index.

Fig. 2. A A. Glass tubes with bulbs. B B. Glasses of water in which they are immersed.

Plate 1.

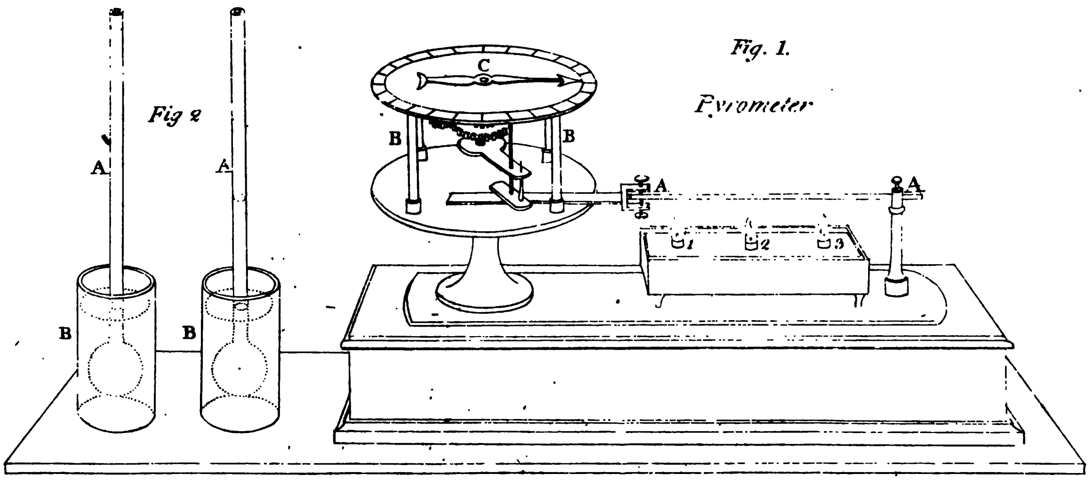


Fig. 1.

Pyrometer

the tube. But water, it seems, is not so easily affected by heat; for no apparent change is produced on it by the warmth of the hand.

Mrs. B. True; we shall now plunge the bulbs into hot water, (*Pate* 1. *Fig.* 2.) and you will see both liquids rise in the tubes; but the spirit of wine will begin to ascend first.

Caroline. How rapidly it dilates! Now it has nearly reached the top of the tube, though the water has not yet began to rise.

Emily. The water now begins to dilate. Are not these glass tubes, with liquids rising within them, very like thermometers?

Mrs. B. A Thermometer is constructed exactly on the same principle, and these tubes require only a scale to answer the purpose of thermometers: but they would be rather awkward in their dimensions. The tubes and bulbs of thermometers, though of various sizes, are in general much smaller than these; the tube too is hermetically closed, and the air excluded from it. The fluid most generally used in thermometers is mercury, commonly called quicksilver, the dilatations and contractions of which correspond more exactly to the additions, and subtractions, of caloric, than those of any other fluid.

Caroline. Yet I have often seen coloured spirits of wine used in thermometers.

Mrs. B. The dilatations and contractions of that liquid are not quite so uniform as those of mercury; but in cases in which it is not requisite to ascertain the temperature with great precision, spirit of wine will answer the purpose equally well, and indeed in some respects better, as the expansion of the latter is greater and therefore more conspicuous. This fluid is used likewise in situations and experiments in which mercury would be frozen; for mercury becomes a solid body, like a piece of lead or any other metal, at a certain degree of cold: but no degree of cold has ever been known to freeze spirits of wine.

A thermometer therefore consists of a tube with a

bulb, such as you see here, containing a fluid whose degrees of dilatation and contraction are indicated by a scale to which the tube is fixed. The degree which indicates the boiling point, simply means that, when the fluid is sufficiently dilated to rise to this point, the heat is such, that water exposed to the same temperature will boil. When, on the other hand, the fluid is so much condensed as to sink to the freezing point, we know that water will freeze at that temperature. The extreme points of the scales are not the same in all thermometers, nor are the degrees always divided in the same manner. In different countries philosophers have chosen to adopt different scales and divisions. The two thermometers most used are those of Fahrenheit, and of Reaumur; the first is generally preferred by the English, the latter by the French.

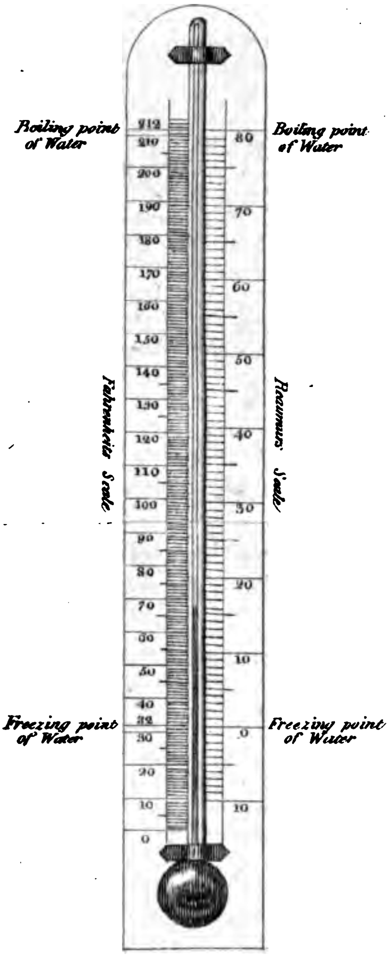
Emily. The variety of scale must be very inconvenient, and I should think liable to occasion confusion, when French and English experiments are compared.

Mrs. B. This inconvenience is but very trifling, because the different graduations of the scales do not affect the principle upon which thermometers are constructed. When we know, for instance, that Fahrenheit's scale is divided into 212 degrees, in which 32° corresponds with the freezing point, and 212° with the point of boiling water; and that Reaumur's is divided only into 80 degrees, in which 0° denotes the freezing point, and 80° that of boiling water, it is easy to compare the two scales together, and reduce the one into the other. But, for greater convenience, thermometers are sometimes constructed with both these scales, one on either side of the tube; so that the correspondence of the different degrees of the two scales, is thus instantly seen. Here is one of these scales (*Plate* II. *Fig.* 3.) by which you can at once perceive that each degree of Reaumur's corresponds to $2\frac{1}{4}$ of Fahrenheit's division.

Emily. Are spirits of wine, and mercury, the only fluids used in the construction of thermometers.

Mrs. B. I believe they are the only liquids now in use, though some others, such as linseed oil, would

THERMOMETER



Drawn by the Author Doolittle S

Engraved for Increase Cooke & C^o. *New Haven*

make tolerable thermometers ; but for experiments in which a very quick and delicate test of the changes of temperature is required, air thermometers are sometimes employed. The bulb, in these, instead of containing a liquid, is filled only with common air, and its dilatations and contractions are made sensible by a small drop of any coloured fluid, which is suspended within the tube, and moves up and down, according as the air within the bulb and tube expands or contracts. But air thermometers, however sensible to changes of temperature, are by no means accurate in their indications.

Emily. A thermometer, then, indicates the exact quantity of caloric contained either in the atmosphere, or in any body with which it is in contact ?

Mrs. B. No : first, because there are other modifications of caloric which do not affect the thermometer ; and, secondly, because the temperature of a body, as indicated by the thermometer, is only relative. When for instance, the thermometer remains stationary at the freezing point, we know that the atmosphere (or medium in which it is placed, whatever it may be) is as cold as freezing water : and when it stands at the boiling point, we know that this medium is as hot as boiling water ; but we do not know the positive quantity of heat contained either in freezing or boiling water, any more than we know the real extremes of heat and cold ; and consequently, we cannot determine that of the body in which the thermometer is placed.

Caroline. I do not quite understand this explanation.

Mrs. B. Let us compare a thermometer to a well, in which the water rises to different heights, according as it is more or less supplied by the spring which feeds it : if the depth of this well be unfathomable, it must be impossible to know the absolute quantity of water it contains ; yet we can with the greatest accuracy measure the number of feet the water has risen or fallen in the well at any time, and consequently know the precise quantity of its increase or diminution, without having the least knowledge of the whole quantity of water it contains.

Caroline. Now I comprehend it very well: nothing explains a thing so clearly as a comparison.

Emily. But will thermometers bear any degree of heat?

Mrs. B. No; for if the temperature be much above the highest degree marked on the scale of the thermometer, the mercury would burst the tube in an attempt to ascend. And at any rate, no thermometer can be applied to temperatures higher than the boiling point of the liquid used in its construction. In furnaces, or whenever any very high temperature is to be measured, a pyrometer, invented by Wedgewood, is used for that purpose. It is made of a certain composition of baked clay, which has the peculiar property of contracting by heat, so that the degree of contraction of this substance indicates the temperature to which it has been exposed.

Emily. But is it possible for a body to contract by heat? I thought that heat dilated all bodies whatever.

Mrs. B. That is, I believe, true. Yet heat frequently diminishes the bulk of a body by evaporating some of its particles; thus, if you dry a wet sponge before the fire, the heat, though it must, according to the general law of nature, dilate the particles of the sponge, will very considerably contract its bulk by evaporating its moisture.

Caroline. And how do you ascertain the degrees of contraction by this pyrometer?

Mrs. B. The dimensions of a piece of clay are measured by the bore of a graduated conical tube in which it is placed; the more it is contracted by the heat, the lower it descends into the narrow part of the tube.

Let us now proceed to examine the other properties of free caloric.

Free caloric always tends to an equilibrium; that is to say, when two bodies are of different temperatures, the warmer gradually parts with its heat to the colder, till they are both brought to the same temperature.

Emily. Is cold then nothing but a negative quality, simply implying the absence of heat?

Mrs. B. Not the total absence, but a diminution of heat; for we know of no body in which some caloric may not be discovered.

Caroline. But when I lay my hand on this marble table, I feel it *positively* cold, and cannot conceive that there is any caloric in it.

Mrs. B. The cold you experience consists in the loss of caloric that your hand sustains in an attempt to bring its temperature to an equilibrium with the marble. If you lay a piece of ice upon it, you will find that the contrary effect will take place; the ice will be melted by the heat which it abstracts from the marble.

Caroline. Is it not in this case the air of the room, which being warmer than the marble, melts the ice?

Mrs. B. The air certainly acts on the surface exposed to it, but the table melts that part which is in contact with it.

Caroline. But why does caloric tend to an equilibrium? It cannot be on the same principle as other fluids, since it has no weight?

Mrs. B. Very true, Caroline, that is an excellent remark. The tendency of caloric to an equilibrium is best explained by a supposed repulsive force of its particles, which having a constant tendency to fly from each other, diffuse themselves wherever there is a deficiency of that fluid, and thus gradually restore an equilibrium of temperature. But it is not only bodies which contain a greater proportion of caloric that part with it to those that contain less: in order to explain all the phenomena of heat and cold, we must suppose that a mutual exchange of caloric takes place between all bodies, of whatever temperature, and that the rays of caloric, in passing from one body to another, are subject to all the laws of reflection and refraction, the same as those of light. This theory was first suggested by Professor Prevost, of Geneva, and is now, I believe, pretty generally adopted. Thus you may suppose all bodies whatever constantly radiating caloric: those that

are of the same temperature give out and receive equal quantities, so that no change of temperature is produced in them; but when one body contains more free caloric than another, the exchange is always in favour of the colder body, until an equilibrium is effected; this you found to be the case when the marble table cooled your hand, and again when it melted the ice.

Caroline. This surprises me extremely: I thought, from what you first said, that the hotter bodies alone emitted rays of caloric which were absorbed by the colder, for it seems unfair that a hot body should receive any caloric from a cold one, even though it should return a greater quantity.

Mrs. B. It may at first appear so, but it is no more extraordinary than that a candle should send forth rays of light to the sun, or that a stone in falling should attract the earth, as you know it does from the law of gravitation.

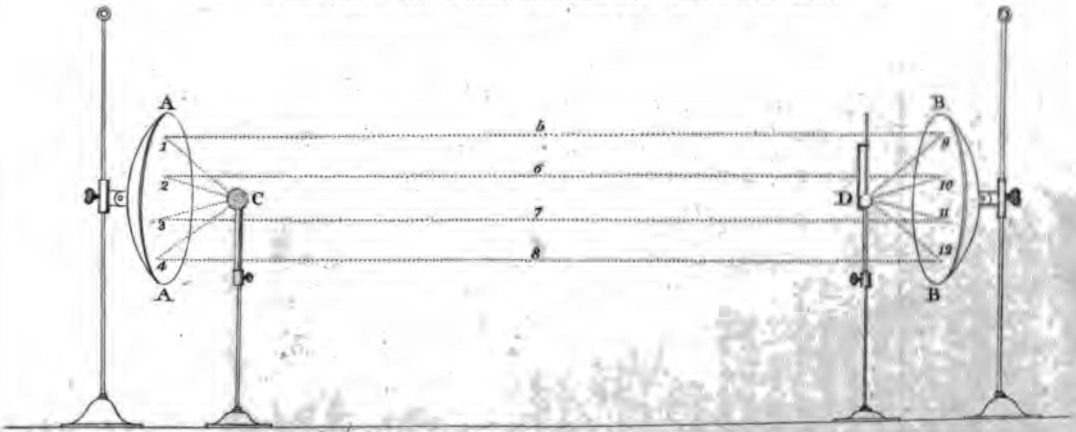
Caroline. Well, Mrs. B. since you have all nature to oppose to me, I believe that I must give up the point. But I wish I could *see* these rays of caloric, I should then have greater faith in them.

Mrs. B. Will you give no credit to any sense but that of sight? You may feel the rays of caloric which you receive from any body of a temperature higher than your own; the loss of the caloric you part with in return, it is true is not perceptible; for as you gain more than you lose, instead of suffering a diminution, you are really making an acquisition of caloric. It is therefore only when you are parting with it to a body of a lower temperature, that you are sensible of the sensation of cold, because you then sustain an absolute loss of caloric.

Emily. And in this case we cannot be sensible of the small quantity of heat we receive in exchange from the colder body, because it serves only to diminish the loss.

Mrs. B. Very well, indeed, Emily. Professor Pictet, of Geneva, has made some very interesting experiments to prove that caloric radiates from all bodies whatever, and that these rays may be reflected, ac-

M^r. PICTETS APPARATUS FOR THE REFLECTION OF HEAT



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; to the laws of optics, in the same manner as I wish I could repeat these experiments before ut the difficulty of procuring mirrors fit for the e puts it out of my power ; you must therefore ified with an account of them, illustrated by this n : *(Plate* III. *Fig.* 4.*)*—He placed an iron bul- out two inches in diameter, and heated to a de- ot sufficient to render it luminous, in the focus of metallic mirror. The rays of heat which fell mirror were reflected, agreeably to the property ave mirrors, in a parrallel direction, so as to fall nilar mirror, which was placed opposite the first, listance of about twelve feet ; thence they con- to the focus of the second mirror, in which the a thermometer was placed, the consequence of was, that the thermometer immediately rose sev- rees.

y. But would not the same effect have taken if the rays of caloric from the heated bullet had lirectly on the thermometer, without the assist- f the mirrors ?

. B. The effect would in that case have been ing, at the distance at which the bullet and the meter were from each other, as would probably endered it imperceptible. The mirrors, you greatly increase the effect, by collecting a large y of rays into a focus ; but their principal use prove that the calorific emanation was reflected same manner as light.

line. And the result I think was very conclu-

. B. The experiment was afterwards repeated wax taper instead of the bullet, with a view of

PLATE III.

and B B. Concave mirrors fixed on stands. C. heated laced in the focus of the mirror A. D. The thermome- its bulb placed in the focus of the mirror B. 1 2 3 4. caloric radiating from the bullet and falling on the mir- 5 6 7 8. The same rays reflected from the mirror A to B. 9 10 11 12. The same rays reflected by the mirror B hermometer.

separating the light from the caloric. For this purpose a transparent plate of glass was interposed between the mirrors; for light you know passes with great facility through glass, whilst the transmission of caloric is considerably impeded by it. It was found however, in this experiment, that some of the calorific rays passed through the glass together with the light, as the thermometer rose a few degrees; but as soon as the glass was removed, and a free passage left to the caloric, it rose immediately double the number of degrees.

Emily. This experiment as well as that of Dr. Herschell's proves that light and heat may be separated; for in the latter experiment the separation was not perfect, any more than in that of Mr. Pictet.

Caroline. I should like to repeat Mr. Pictet's experiments, with the difference of substituting a cold body instead of the hot one, to see whether cold would not be reflected as well as heat.

Mrs. B. That experiment was proposed to Mr. Pictet by an incredulous philosopher like yourself, and he immediately tried it by substituting a piece of ice in the place of the heated bullet.

Caroline. Well, Mrs. B. and what was the result?

Mrs. B. The thermometer fell considerably.

Caroline. And does that not prove that cold is not merely a *negative* quality, implying simply an inferior degree of heat? The cold must be *positive*, since it is capable of reflection.

Mrs. B. So it at first appeared; but upon a little consideration it was found that it afforded only an additional proof of the reflection of heat: this I shall endeavour to explain to you.

We suppose that all bodies whatever radiate caloric; the thermometer used in these experiments therefore emits calorific rays in the same manner as any other substance. When its temperature is in equilibrium with that of the surrounding bodies, it receives as much caloric as it parts with, and no change of temperature is produced. But when we introduce a body of a lower temperature, such as a piece of ice, which parts

with less caloric than it receives, the consequence is, that its temperature is raised, whilst that of the surrounding bodies is proportionably lowered; and as, from the effect of the mirrors, a more considerable exchange of rays takes place between the ice and the thermometer, than between these and any of the surrounding bodies, the temperature of the thermometer must be more lowered than that of any other adjacent object.

Caroline. I do not perfectly understand your explanation.

Mrs. B. This experiment is exactly similar to that made with the heated bullet: for, if we consider the thermometer as the hot body (which it certainly is in comparison to the ice), you may then easily understand that it is by the loss of the calorific rays which the thermometer sends to the ice, and not by any cold rays received from it, that the fall of the mercury is occasioned; for the ice, far from emitting rays of cold, sends forth rays of caloric, which diminish the loss sustained, by the thermometer.

Let us say, for instance, that the radiation of the thermometer towards the ice is equal to 20, and that of the ice towards the thermometer to 10; the exchange in favour of the ice is as 20 is to 10, or the thermometer absolutely loses 10, whilst the ice gains 10.

Caroline. But if the ice actually sends rays of caloric to the thermometer, must not the latter fall still lower when the ice is removed?

Mrs. B. No; for the air which will fill the space that the ice occupied, being of the same temperature as the thermometer, will emit and receive an equal quantity of caloric, so that no alteration of temperature will be produced.

Caroline. I must confess that you have explained this in so satisfactory a manner that I cannot help being convinced that cold has no real claim to the rank of a positive being. So now we may proceed to the other modifications of caloric.

Mrs. B. We have not ye concluded our observations on free caloric. But I shall defer, till our next meeting, what I have further to say on this subject, as I believe it will afford us ample conversation for another interview.

Conversation III.

Continuation of the Subject.

Mrs. B.

In our last conversation, we began to examine the constant tendency of free caloric to restore an equilibrium of temperature. This property, when once well understood, affords the explanation of a great variety of facts which appeared formerly unaccountable. You must observe, in the first place, that the effect of this tendency is gradually to bring all bodies that are in contact, to the same temperature. Thus, the fire which burns in the grate, communicates its heat from one object to another, till every part of the room has an equal proportion of it.

Emily. And yet this book is not so cold as the table on which it lies, though both are at an equal distance from the fire, and actually in contact with each other, so that, according to your theory, they should be exactly of the same temperature?

Caroline. And the hearth, which is much nearer the fire than the carpet, is certainly the colder of the two.

Mrs. B. If you ascertain the temperature of these several bodies by a thermometer (which is a much more accurate test than your feeling), you will find that it is exactly the same.

Caroline. But if they are of the same temperature, why should the one feel colder than the other?

Mrs. B. The hearth and the table feel colder than the carpet or the book, because the latter are not such good *conductors of heat* as the former. Caloric finds a more easy passage through marble and wood, than through leather and worsted; the two former will therefore absorb heat more rapidly from your hand, and consequently give it a stronger sensation of cold than the two latter, although they are all of them really of the same temperature.

Caroline. So, then, the sensation I feel on touching a cold body, is in proportion to the rapidity with which my hand yields its heat to that body?

Mrs. B. Precisely; and, if you lay your hand successively on every object in the room, you will discover which are good, and which are bad conductors of heat, by the different degrees of cold you feel. But in order to ascertain this point, it is necessary that the several substances should be of the same temperature, which will not be the case with those that are very near the fire, or those that are exposed to a current of cold air from a window or door.

Emily. But what is the reason that some bodies are better conductors of heat than others?

Mrs. B. That is a point not well ascertained. It is conjectured that a certain union or adherence takes place between the caloric and the particles of the body through which it passes. If this adherence be strong, the body detains the heat, and parts with it slowly and reluctantly; if slight, it propagates it freely and rapidly. The conducting power of a body is therefore, inversely, as its tendency to unite with caloric.

Emily. That is to say, that the best conductors are those that have the least affinity for caloric.

Mrs. B. Yes; but I object to the term affinity in this case, because as that word is used to express a chemical attraction (which can be destroyed only by decomposition), it cannot be applicable to the slight and transient union that takes place between free caloric and the bodies through which it passes; an union which is

so weak, that it constantly yields to the tendenc caloric has to an equilibrium. Now you clearl stand, that the passage of caloric, through bod are good conductors, is much more rapid than those that are bad conductors, and that the forn give and receive it more quickly, and therefor given time, more abundantly, than bad con which makes them feel either hotter or colder, they may be in fact, of the same temperature.

Caroline. Yes, I understand it now ; the tal the book lying upon it, being really of the san perature, would each receive in the same space the same quantity of heat from my hand, we conducting powers equal ; but as the table is conductor of the two, it will absorb the heat fi hand more rapidly, and consequently produce a er sensation of cold than the book.

Mrs. B. Very well, my dear ; and observ wise, that if you were to heat the table and th an equal number of degrees above the temp of your body, the table which before felt the would now feel the hotter of the two ; for as in case it took the heat more rapidly from your h it will now impart heat most rapidly to it. T marble table, which seems to us colder than t hogany one, will prove the hotter of the two to for if it takes heat more rapidly from our hands are warmer, it will give out heat more rapidly ice, which is colder. Do you understand the r these apparently opposite effects ?

Emily. Perfectly. A body that is a good co of caloric, affords it a free passage ; so that i trates through that body more rapidly than

bodies of the same temperature is equal. Now, can you tell me why flannel clothing, which is a very bad conductor of heat, prevents our feeling cold?

Caroline. It prevents the cold from penetrating.

Mrs. B. But you forget that cold is only a negative quality.

Caroline. True; it only prevents the heat of our bodies from escaping so rapidly as it would otherwise do.

Mrs. B. Now you have explained it right: the flannel rather keeps in the heat, than keeps out the cold. Were the atmosphere of a higher temperature than our bodies, it would be equally efficacious in preserving them of an uniform temperature, as it would prevent the free access of the external heat, by the difficulty with which it conducts it.

Emily. This, I think, is very clear. Heat, whether external or internal, cannot easily penetrate flannel; therefore in cold weather it keeps us warm; and if the weather was hotter than our bodies, it would keep us cool.

Mrs. B. For the same reason, glass windows, which are very bad conductors of heat, keep a room warm in winter and cool in summer, provided the sun does not shine upon them. The most dense bodies are, generally speaking, the best conductors of heat. At the temperature of the atmosphere a piece of metal will feel much colder than a piece of wood, and the latter than a piece of woollen cloth: this again will feel colder than flannel; and down, which is one of the lightest, is at the same time, one of the warmest bodies.

Caroline. This is, I suppose, the reason that the plumage of birds preserves them so effectually from the influence of cold in winter?

Mrs. B. Yes; but though feathers in general are an excellent preservative against cold, down is a kind of plumage peculiar to aquatic birds, and covers their chest, which is the part exposed to the water; for though the surface of the water is not of a lower temperature than the atmosphere, yet, as it is a better

conductor of heat, it feels much colder, consequently the chest of the bird requires a warmer covering than any other part of its body.

Most animal substances, especially those which Providence has assigned as a covering for animals, such as fur, wool, hair, skin, &c. are bad conductors of heat, and are, on that account such excellent preservatives against the inclemency of winter, that our warmest apparel is made of these materials.

In fluids of different densities, the power of conducting heat varies no less remarkably; if you dip your hand into this vessel full of mercury, you will scarcely conceive that its temperature is not lower than that of the atmosphere.

Caroline. Indeed I can hardly believe it, it feels so extremely cold.—But we may easily ascertain its true temperature by the thermometer.—It is really not colder than the air;—the apparent difference then is produced merely by the difference of the conducting power in mercury and in air?

Mrs. B. Yes; hence you may judge how little the sense of feeling is to be relied on as a test of the temperature of bodies, and how necessary a thermometer is for that purpose.

But I must not forget to tell you, that it has been doubted whether fluids have the power of conducting caloric in the same manner as solid bodies. Count Rumford a very few years since, attempted to prove, by a variety of experiments, that fluids, when at rest, were not at all endowed with this property.

Caroline. How is that possible, since they are capable of imparting cold or heat to us; for if they did not conduct heat, they would neither take it from, nor give it to us?

Mrs. B. Count Rumford did not mean to say that fluids do not communicate their heat to solid bodies; but only that heat does not pervade fluids, that is to say, is not transmitted from one particle of a fluid to another, in the same manner as in solid bodies.

Emily. But when you heat a vessel of water over the fire, if the particles of water do not communicate

heat to each other, how does the water become hot throughout?

Mrs. B. By constant agitation. Water as you have seen, expands by heat in the same manner as solid bodies; the heated particles of water therefore, at the bottom of the vessel, become specifically lighter than the rest of the liquid, and consequently ascend to the surface, where, parting with some of their heat to the colder atmosphere, they are condensed, and give way to a fresh succession of heated particles ascending from the bottom, which having thrown off their heat at the surface, are in their turn displaced. Thus every particle is successively heated at the bottom, and cooled at the surface of the liquid; but as the fire communicates heat more rapidly than the atmosphere cools the succession of surfaces, the whole of the liquid in time becomes heated.

Caroline. This accounts most ingeniously for the propagation of heat upwards. But suppose you were to heat the upper surface of a liquid, the particles being specifically lighter than those below, could not descend: how therefore would the heat be communicated downwards?

Mrs. B. Count Rumford assures us, that if there was no agitation to force the heated surface downwards, the heat would not descend. In proof of this, he succeeded in making the upper surface of a vessel of water boil and evaporate, while a cake of ice remained frozen at the bottom.

Caroline. That is very extraordinary indeed!

Mrs. B. It appears so, because we are not accustomed to heat liquids by their upper surface, but you will understand this theory better if I shew you the internal motion that takes place in liquids when they experience a change of temperature. The motion of the liquid itself is indeed invisible from the extreme minuteness of its particles; but if you mix with it any coloured dust, or powder, of nearly the same specific gravity as the liquid, you may judge of the internal motion of the latter by that of the coloured dust it contains. Do you see the small pieces of amber moving about in the liquid contained in this phial.

Caroline. Yes, perfectly.

Mrs. B. We shall now immerse the phial in a glass of hot water, and the motion of the liquid will be shown, by that which it communicates to the amber.

Emily. I see two currents, the one rising along the sides of the phial, the other descending in the centre; but I do not understand the reason of this.

Mrs. B. The hot water communicates its caloric, through the medium of the phial, to the particles of the fluid nearest to the glass; these dilate and ascend laterally to the surface, where, in parting with their heat, they are condensed, and in descending, form the central current.

Caroline. This is indeed a very clear and satisfactory experiment; but how much slower the currents now move than they did at first?

Mrs. B. It is because the circulation of particles has nearly produced an equilibrium of temperature between the liquid in the glass and that in the phial.

Caroline. But these communicate laterally, and I thought that heat in liquids could be propagated only upwards?

Mrs. B. You do not take notice that the heat is imparted from one liquid to the other, through the medium of the phial itself, the external surface of which receives the heat from the water in the glass, whilst its internal surface transmits it to the liquid it contains.—Now take the phial out of the hot water, and observe the effects of its cooling.

Emily. The currents are reversed; the external current now descends, and the internal one rises. I guess the reason of this change:—the phial being in contact with cold air instead of hot water, the external particles are cooled instead of being heated; they therefore descend and force up the central particles, which being warmer are consequently ligher.

Mrs. B. It is just so. Count Rumford infers from hence, that no alteration of temperature can take place in a fluid, without an internal motion of its particles, and as this motion is produced only by the comparative levity of the heated particles, heat cannot be propagated downwards.

This theory explains the reason of the cold that is found to prevail at the bottom of the lakes in Switzerland, which are fed by rivers issuing from the snowy Alps. The water of these rivers being colder, and therefore more dense than that of the lakes, subsides to the bottom, where it cannot be affected by the warmer temperature of the surface; the motion of the waves may communicate this temperature to some little depth, but it can descend no further than the agitation extends.

Emily. But when the atmosphere is colder than the lake, the colder surface of the water will descend for the very reason that the warmer will not?

Mrs. B. Certainly; and it is on this account that neither a lake nor any body of water whatever, can be frozen until every particle of the water has risen to the surface to give off its caloric to the colder atmosphere; therefore the deeper a body of water is, the longer will be the time it requires to be frozen.

Emily. But if the temperature of the whole body of water is brought down to the freezing point, why is only the surface frozen?

Mrs. B. The temperature of the whole body is lowered, but not to the freezing point. The diminution of heat as you know, produces a contraction in the bulk of fluids, as well as of solids. This effect however does not take place in water below the temperature of forty degrees, which is eight degrees above the freezing point. At that temperature, therefore, the internal motion, occasioned by the increased specific gravity of the condensed particles, ceases; for when the water at the surface no longer condences, it will no longer descend, and leave a fresh surface exposed to the atmosphere: this surface alone, therefore, will be further exposed to its severity, and will soon be brought down to the freezing point, when it becomes ice, which being a bad conductor of heat, preserves the water beneath a long time from being affixed by the external cold.

Caroline. And the sea does not freeze, I suppose, because its depth is so great, that a frost never lasts long enough to bring down the temperature of such a great body of water to forty degrees?

Mrs. B. No, that is not the case; for salt water is an exception to this law, as it condenses even many degrees below the freezing point. When the caloric of fresh water therefore is imprisoned by the ice, the ocean still continues throwing off heat into the atmosphere, which is a most signal dispensation of Providence to moderate the intensity of the cold in winter.

Emily. I admire this theory extremely;* but allow me to ask you one more question relative to it. You said that when water was heated over the fire, the particles at the bottom of the vessel ascended as soon as heated, in consequence of their specific levity; why does not the same effect continue when the water boils, and is converted into steam? and why does the steam rise from the surface instead of the bottom of the liquid?

Mrs. B. The steam or vapour does ascend from the bottom, though it seems to arise from the surface of the liquid. We shall boil some water in this Florence flask; (*Plate IV. Fig. 5.*) you will then see through the glass, that the vapour rises in bubbles from the bottom. We shall make it boil by means of a lamp, which is more convenient for this purpose than the chimney fire.——

Emily. I see some small bubbles ascend, and a great many appear all over the inside of the flask; does the water begin to boil already?

Mrs. B. No; what you now see are bubbles of air which were either enclosed in the water, or attached to the inner surface of the flask, and which, being rarefied by the heat, ascend in the water.

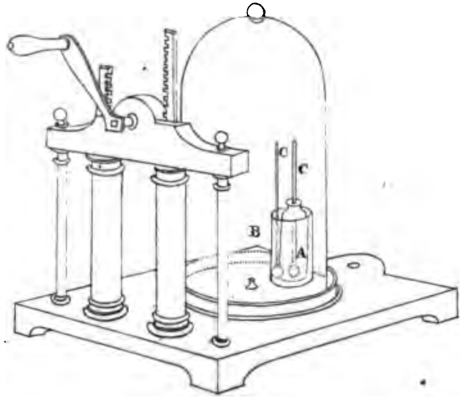
PLATE IV.

Fig 5. Boiling water in a flask over a patent lamp.
Fig. 6. Ether evaporated and water frozen in the air pump.
A. A phial of ether. B. Glass vessel containing water. C. C. Thermometers, one in the ether, the other in the water.

* This theory of the non-conducting power of fluids, notwithstanding all its plausibility, has been found, by a variety of subsequent experiments, to have been carried by Count Rumford, rather too far; and it is now generally admitted that fluids are not entirely destitute of conductibility, though they propagate heat chiefly by motion, in the manner just explained, and possess the conducting power but in a very imperfect degree.

Fig. 6.

Pneumatic Pump



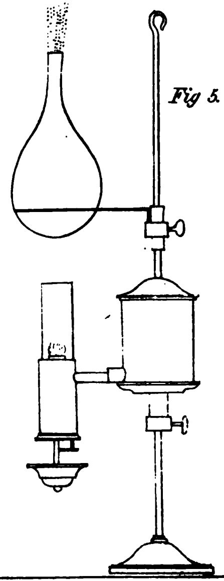


Fig 5.

Drawn by the Author

Engraved for Increase Cooke & C° New Haven

Doolittle Sc.

Emily. But the heat which rarefies the air enclosed in the water, must rarefy the water at the same time; therefore, if it could remain stationary in the water when both were cold, I do not understand why it should not when both are equally heated?

Mrs. B. Air being much less dense than water, is more easily rarefied; the former therefore expands to a greater extent, whilst the latter continues to occupy nearly the same space; for water dilates comparatively but very little without changing its state and becoming vapour. Now that the water in the flask begins to boil, observe what large bubbles rise from the bottom of it.

Emily. I see them perfectly; but I wonder that they have sufficient power to force themselves through the water.

Caroline. They must rise, you know, from their specific levity.

Mrs. B. You are right, Caroline; but vapour has not in all liquids (when brought to the degree of vaporisation) the power of overcoming the pressure of the less heated surface. Metals for instance, evaporate only from the surface; therefore no vapour will ascend from them till the degree of heat which is necessary to form it has reached the surface; that is to say till the whole of the liquid is brought to the boiling point. This is the case with all metals, mercury alone excepted.

Emily. I have observed that steam, immediately issuing from the spout of a tea-kettle, is less visible than at a further distance from it; yet it must be more dense when it first evaporates than when it begins to diffuse itself in the air.

Mrs. B. Your objection is a very natural one; and in order to answer it, it will be necessary for me to enter into some explanation respecting the nature of SOLUTION. Solution takes place whenever a body is melted in a fluid. In this operation the body is reduced to such a minute state of division by the fluid, as to become invisible in it, and to partake of its fluidity: but this happens without any decomposition, the body being on-

ly divided into its integrant particles by the fluid in which it is melted.

Caroline. It is then a mode of destroying the attraction of aggregation.

Mrs. B. Undoubtedly.—The two principal solvent fluids are *water* and *caloric*. You may have observed that if you melt salt in water, it totally disappears, and the water remains clear and transparent as before; yet though the union of these two bodies appears so perfect, it is not produced by any chemical combination: both the salt and the water remain unchanged; and if you were to separate them by evaporating the latter, you would find the salt in the same state as before.

Emily. I suppose that water is a solvent for solid bodies, and caloric for liquids?

Mrs. B. Liquids of course can only be converted into vapour by caloric. But the solvent power of this agent is not at all confined to that class of bodies; a great variety of solid substances are dissolved by heat: thus metals, which are insoluble in water, can be dissolved by intense heat, being first fused or converted into a liquid, and then rarefied into an invisible vapour. Many other bodies, such as salts, gums, &c. yield to either of these solvents.

Caroline. And that, no doubt, is the reason why hot water will melt them so much better than cold water?

Mrs. B. It is so. Caloric may indeed be considered as having, in every instance, some share in the solution of a body by water, since all water, however low its temperature may be, always contains more or less caloric.

Emily. Then perhaps water owes its solvent power merely to the caloric it contains?

Mrs. B. That probably would be carrying the speculation too far; I should rather think that water and caloric unite their efforts to dissolve a body, and that the difficulty or facility of effecting this, depends both on the degree of attraction of aggregation to be overcome, and on the arrangement of the particles which are more or less disposed to be divided and penetrated by the solvent.

Emily. But have not all liquids the same solvent power as water?

Mrs. B. The solvent power of other liquids varies according to their nature, and that of the substance submitted to their action. Most of these solvents, indeed, differ essentially from water, as they do not merely separate the integrant particles of the bodies which they dissolve, but attack their constituent principles by the power of chemical attraction, thus producing a true decomposition. These more complicated operations, which may be distinguished by the name of *chemical solutions*, we must consider in another place, and confine our attention at present to the simple solutions by water and caloric.

Caroline. But there are a variety of substances which, when dissolved in water, make it thick and muddy, and destroy its transparency.

Mrs. B. In this case it is not a solution, but simply a mixture. I shall show you the difference between a solution and a mixture, by putting some common salt into one glass of water, and some powder of chalk into another; both these substances are white, but their effect on the water will be very different.

Caroline. Very different indeed! the salt entirely disappears and leaves the water transparent, whilst the chalk changes it into an opake liquid like milk.

Emily. And would lumps of chalk and salt produce similar effects on water?

Mrs. B. Yes, but not so rapidly; salt is indeed soon melted though in a lump, but chalk which does not mix so readily with water, would require a much greater length of time; I therefore preferred showing you the experiment with both substances reduced to powder, which does not in any respect alter their nature, but fecilitates the operation merely by presenting a greater quantity of surface to the water.

I must not forget to mention a very curious circumstance respecting solutions, which is, that a fluid is not increased in bulk by holding a body in solution.

Caroline. That seems impossible; for two bodies cannot exist together in the same space.

Mrs. B. That is true, my dear; but two bodies may, by condensation, occupy the same space which one of them filled before. It is supposed that there are pores or interstices, in which the salt lodges, between the minute particles of the water. And these spaces are so small that the body to be dissolved must be divided into very minute particles in order to be contained in them; and it is this state of very great division that renders them invisible.

Caroline. I can try this experiment immediately. —It is exactly so—the water in this glass, which I filled to the brim, is melting a considerable quantity of salt without overflowing. I shall try to add a little more.—But now, you see, Mrs. B. the water runs over.

Mrs. B. Yes; but observe that the last quantity of salt you put in remains solid at the bottom, and displaces the water; for it has already melted all the salt it is capable of holding in solution. This is called the point of *saturation;* and the water is now said to be *saturated* with salt.

Emily. This happens, I suppose, when the interstices between the particles of the liquid are completely filled?

Mrs. B. Probably. But these remarks, you must observe do not apply to a mixture; for any substance which does not dissolve, increases the bulk of the liquid.

Emily. I think I now understand the solution of a solid body by water perfectly: but I have not so clear an idea of the solution of a liquid by caloric.

Mrs. B. It is precisely of the same nature; but as caloric is an invisible fluid, its action as a solvent is not so obvious as that of water. Caloric dissolves water, and converts it into vapour by the same process as water dissolves salt; that is to say, the particles of water are so minutely divided by the caloric as to become invisible. Thus, you are now enabled to understand why the vapour of boiling water, when it first issues from the spout of a kettle, is invisible; it is so, because it is then completely dissolved by caloric. But the air

with which it comes in contact, being much colder than the vapour, the latter yields to it a quantity of its caloric. The particles of vapour being thus in a great measure deprived of their solvent, gradually collect and become visible in the form of steam, which is water in a state of imperfect solution; and if you were further to deprive it of its caloric, it would return to its original liquid state.

Caroline. That I understand very well; but in what state is the steam, when it again becomes invisible by being diffused in the air?

Mrs. B. It is carried off and again dissolved by the air.

Emily. The air then has a solvent power, like water and caloric?

Mrs. B. Its solvent power proceeds chiefly, if not entirely, from the caloric contained in it, the atmosphere acting only as a vehicle. Sometimes the watery vapour diffused in the atmosphere is but imperfectly dissolved, as is the case in the formation of clouds and fogs; but if it gets into a region of air sufficiently warm, it becomes perfectly invisible.

Emily. Does the air ever dissolve water, without its being previously converted into vapour by boiling?

Mrs. B. Yes, it does. Water when heated to the boiling point, can no longer exist in the form of water, and must necessarily be converted into vapour, whatever may be the state and temperature of the surrounding medium; but the air (by means probably of the caloric it contains) can take up a certain portion of water at any temperature, and hold it in a state of solution. Thus the atmosphere is continually carrying off moisture from the earth, until it is saturated with it.

The tendency of free caloric to an equilibrium, together with its solvent power, are likewise connected with the phenomena of rain, of dew, &c. When a cloud of a certain temperature happens to pass through a colder region of the atmosphere, it parts with a portion of its heat to the surrounding air; the quantity of caloric therefore, which served to keep the cloud in a state of vapour, being diminished, the watery particles

approach each other, and form themselves into drops of water, which being heavier than the atmosphere, descend to the earth. There are also other circumstances, and particularly the variation in the weight of the atmosphere, which may contribute to the formation of rain. This however, is an intricate subject, into which we cannot more fully enter at present.

Emily. But in what manner do you account for the formation of dew?

Mrs. B. During the heat of the day the air is able to retain a greater quantity of vapour in a state of solution, than either in the morning or evening. As soon, therefore, as a diminution of heat takes place towards sun-set, a quantity of vapour is condensed, and falls to the ground in form of dew. The morning dew, on the contrary, rises from the earth; but when the sun has emitted a sufficient quantity of caloric to dissolve it, it becomes invisible in the atmosphere. When once the dew, or any liquid whatever, is perfectly dissolved by the air, it occasions no humidity; it is only when in a state of imperfect solution, and floating in the form of watery vapour in the atmosphere, that it produces dampness.

Caroline. I have often observed, Mrs B. that when I walk out in frosty weather, with a veil over my face, my breath freezes upon it. Pray what is the reason of that?

Mrs. B. It is because the cold air immediately seizes on the caloric of your breath, and reduces it, by robbing it of its solvent, to a denser fluid, which is the watery vapour that settles on your veil, and there it continues parting with its caloric till it is brought down to the temperature of the atmosphere, and assumes the form of ice.

You may, perhaps, have observed that the breath of animals, or rather the moisture contained in it, is visible during a frost, but not in warm weather.* In the latter case, the air is capable of retaining it in a state

* Unless in very damp weather, when the atmosphere is already saturated with moisture.

of solution, whilst in the former, the cold condenses it into visible vapour ; and for the same reason, the steam arising from water that is warmer than the atmosphere, is visible. Have you never taken notice of the vapour rising from your hands after having dipped them into warm water ?

Caroline. Often, especially in frosty weather ?

Mrs. B. When a bottle of wine is taken fresh from the cellar (in summer particularly), it will soon be covered with dew ; and even the glasses in which the wine is poured will be moistened with a similar vapour. Let me hear if you can account for this ?

Emily. The bottle is colder than the surrounding air, therefore it must absord caloric from it ; the moisture which that air held in solution must become visible, and form the dew which is deposited on the bottle.

Mrs. B. Very well, Emily. Now, Caroline, can you tell me why, in a warm room, or close carriage, the contrary effect takes place ; that is to say, that the inside of the windows are covered with vapour ?

Caroline. I have heard that it proceeds from the breath of those within the carriage ; and I suppose it is occasioned by the windows which, being colder than the breath, deprive it of part of its caloric, and by this means convert it into a watery vapour.

Mrs. B. Very well, my dear : I am extremely glad to find that you both understand the subject so well.

We have already observed that pressure is an obstacle to evaporation : there are liquids that contain so great a quantity of caloric, and whose particles consequently adhere so slightly together, that they may be converted into vapour without any elevation of temperature, merely by taking off the weight of the atmosphere. In such liquids, you perceive, it is the pressure of the atmosphere alone that connects their particles and keeps them in a liquid state.

Caroline. I do not well understand why the particles of such fluids should be disunited and converted into vapour, without any addition of heat, in spite of the attraction of cohesion ?

Mrs. B. It is because the quantity of caloric which enters into the formation of these fluids is sufficient to overcome their attraction of cohesion. Ether is of this description; it will boil and be converted into vapour, without any application of heat, if the pressure of the atmosphere be taken off.

Emily. I thought that ether would evaporate without either taking away the pressure of the atmosphere, or applying heat, and that it was for that reason so necessary to keep it carefully corked up.

Mrs. B. That is true; but in this case it will evaporate but very slowly. I am going to show you how suddenly the ether in this phial will be converted into vapour, by means of the air pump.—Observe with what rapidity the bubbles ascend, as I take off the pressure of the atmosphere.

Caroline. It positively boils: how singular to see a liquid boil without heat!

Mrs. B. Now I shall place the phial of ether in this glass, which it nearly fits, so as to leave only a small space, which I fill with water; and in this state I put it again under the receiver. (*Plate* IV. *Fig.* 6.)* —You will observe, as I exhaust the air from it, that whilst the ether boils, the water freezes.

Caroline. It is indeed wonderful to see water freeze by means of a boiling fluid!

Emily. There is another circumstance which I am unable to account for. How can the ether change to a state of vapour, without an addition of caloric; for it must contain more caloric in a state of vapour, than in a state of liquidity; and though you say that it is the

* Two pieces of thin glass tubes, sealed at one end, might answer this purpose better. The experiment, however, as here described, is difficult, and requires a very nice apparatus. But if instead of phials or tubes, two watch glasses be used, water may be frozen almost instantly in the same manner. The two glasses are placed over one another, with a few drops of water interposed between them, and the uppermost glass is filled with ether. After working the pump for a minute or two, the glasses are found to adhere strongly together, and a thin layer of ice is seen between them.

pressure of the atmosphere which condenses it into a liquid, it must be, I suppose, by forcing out part of the caloric that belongs to it when in an aeriform state?

Mrs. B. You are right. Ether, in a liquid state, does not contain a sufficient quantity of caloric to become vapour. I have therefore, two difficulties to explain; first, from whence the ether obtains the caloric necessary to convert it into vapour when it is relieved from the pressure of the atmosphere; and, secondly, what is the reason that the water, in which the bottle of ether stands, is frozen?

Caroline. Now I think I can answer both these questions. The ether obtains the addition of caloric required from the water in the glass; and the loss of caloric, which the latter sustains, is the occasion of its freezing.

Mrs. B. You are perfectly right; and if you look at the thermometer which I have placed in the water, whilst I am working the pump, you will see that every time bubbles of vapour are produced, the mercury descends; which proves that the heat of the water diminishes in proportion as the ether boils.

Emily. This I understand now very well; but if the water freezes in consequence of yielding its caloric to the ether, the equilibrium of heat must in this case, be totally destroyed. Yet you have told us, that bodies of a different temperature are always communicating their heat to each other, till it becomes every where equal; and besides, I do not see why the water, though originally of the same temperature as the ether, gives out caloric to it, till the water is frozen and the ether made to boil.

Mrs. B. I suspected that you would make these objections; and in order to remove them, I enclosed two thermometers in the air-pump; one of which stands in the glass of water, the other in the phial of ether; and you may see that the equilibrium of temperature is not destroyed; for as the thermometer descends in the water, that in the ether sinks in the same manner; so that both thermometers indicate the same temperature, though one of them is in a boiling, the other in a freezing liquid.

Emily. The ether then becomes colder as it boils? This is so contrary to common experience, that I confess it astonishes me exceedingly.

Caroline. It is, indeed, a most extraordinary circumstance. But pray how do you account for it?

Mrs. B. I cannot satisfy your curiosity at present; for before we can attempt to explain this apparent paradox, we must become acquainted with the subject of LATENT HEAT; and that, I think, we must defer till our next interview.

Caroline. I believe, Mrs. B. that you are glad to put off the explanation; for it must be a very difficult point to account for.

Mrs. B. I hope, however, that I shall do it to your complete satisfaction.

Emily. But before we part, give me leave to ask you one question. Would not water, as well as ether, boil with less heat, if the pressure of the atmosphere were taken off?

Mrs. B. Undoubtedly. You must always recollect that there are two forces to overcome, in order to make a liquid boil, or evaporate; the attraction of aggregation, and the weight of the atmosphere. On the summit of a high mountain (as Mr. De Saussure ascertained on Mount Blanc) less heat is required to make water boil than in the plain, where the weight of the atmosphere is greater. But I can show you a very pretty experiment, which proves the effect of the pressure of the atmosphere in this respect.

Observe, that this Florence flask is about half full of water, and the upper half of invisible vapour, the water being in the act of boiling.—I take it from the lamp and cork it carefully—the water, you see, immediately ceases boiling.—I shall now wrap a cold wet cloth round the upper part of the flask*——

Caroline But look, Mrs. B. the water begins to boil

* Or the whole flask may be dipped in a bason of cold water. In order to ſhow how much the water cools whilst it is boiling, a thermometer, graduated on the tube itself, may be introduced into the bottle through the cork.

again, although the wet cloth must rob it more and more of its caloric! What can be the reason of that?

Mrs. B. Let us examine its temperature. You see the thermometer immersed in it remains stationary at 180 degrees, which is about 30 degrees below the boiling point. When I took the flask from the lamp, I observed to you that the upper part of it was filled with vapour; this being compelled to yield its caloric to the wet cloth, was again converted into water—What then filled the upper part of the flask?

Emily. Nothing; for it was too well corked for the air to gain admittance, and therefore the upper part of the flask must be a vacuum.

Mrs. B. If the upper part of the flask be a vacuum, the water below no longer sustains the pressure of the atmosphere, and will therefore boil at a much lower temperature. Thus, you see, though it had lost many degrees of heat, it began boiling again the instant the vacuum was formed above it. The boiling has now ceased: if it had been ether, instead of water, it would have continued boiling much longer; but water being a more dense fluid, requires a more considerable quantity of caloric to make it evaporate, even when the pressure of the atmosphere is removed.

Emily. But if the pressure of the atmosphere keeps the particles of ether together, why does it evaporate when exposed to the air? Nay, does not even water, the particles of which adhere so strongly together, slowly evaporate in the atmosphere?

Mrs. B. I have already told you that air has the power of keeping a certain quantity of vapour in solution at any known temperature; and being constantly in a state of motion, and incessantly renewing itself on the surface of the liquid, it skims off, and gradually dissolves new quantities of vapour. Water also has the power of absorbing a certain quantity of air, so that their action on each other is reciprocal; the air thus enclosed in water is that which you see evaporate in bubbles when water is heated previous to its boiling.

Emily. What proportion of vapour can air contain in a state of solution?

Mrs. B. I do not know whether it has been exactly ascertained by experiment; but at any rate this proportion must vary, both according to the temperature and the weight of the atmosphere; for the lower the temperature, and the greater the pressure, the smaller must be the proportion of vapour that air can contain in a state of solution. But we have dwelt so long on the subject of free caloric, that we must reserve the other modifications of that fluid to our next meeting, when we shall endeavour to proceed more rapidly.

Conversation IV.

On Specific Heat, Latent Heat, and Chemical Heat.

Mrs. B.

We are now to examine the three other modifications of caloric.

Caroline. I am very curious to know of what nature they can be; for I have no notion of any kind of heat that is not perceptible to the senses.

Mrs. B. In order to enable you to understand them, it will be necessary to enter into some previous explanations.

It has been discovered by modern chemists, that bodies of a different nature, heated to the same temperature, do not contain the same quantity of caloric.

Caroline. How could that be ascertained?

Mrs. B. It was found that, in order to raise the temperature of different bodies the same number of degrees, different quantities of caloric were required for each of them. If, for instance, you place a pound of

lead, a pound of chalk, and a pound of milk, in a hot oven, they will be gradually heated to the temperature of the oven; but the lead will attain it first, the chalk next, and the milk last.

Emily. As they were all of the same weight, and exposed to the same heat, I should have thought that they would have attained the temperature of the oven at the same time.

Caroline. And how is it that they do not?

Mrs. B. It is supposed to be on account of the different capacity of these bodies for caloric.

Caroline. What do you mean by the *capacity* of a body for caloric?

Mrs. B. I mean a certain disposition of bodies to admit more or less caloric between their minute particles.

Let us put as many marbles into this glass as it will contain, and pour some sand over them—observe how the sand penetrates and lodges between them. We shall now fill another glass with pebbles of various forms—you see that they arrange themselves in a more compact manner than the marbles, which, being globular, can touch each other by a single point only. The pebbles, therefore, will not admit so much sand between them; and consequently one of these glasses will necessarily contain more sand than the other, though both of them be equally full.

Caroline. This I understand perfectly. The marbles and the pebbles represent two bodies of different kinds, and the sand the caloric contained in them; and it appears very plain, from this comparison, that one body may admit of more caloric between its particles than another.

Mrs. B. If you understand this, you can no longer be surprised that bodies of a different capacity for caloric should require different proportions of that fluid to raise their temperatures equally.

Emily. But I do not understand why the body that contains the most caloric should not be of the highest temperature; that is to say, feel hot in proportion to the quantity of caloric it contains?

Mrs. B. The caloric that is employed in filling the capacity of a body, is not free caloric; but it is imprisoned as it were in the body, and is therefore imperceptible; for we can feel only the free radiating caloric which the body parts with, and not that which it retains.

Caroline. It appears to me very extraordinary that heat should be confined in a body in such a manner as to be imperceptible.

Mrs. B. If you lay your hand on a hot body, you feel only the caloric which leaves it, and enters your hand; for it is impossible that you should be sensible of that which remains in the body. The thermometer, in the same manner, is affected only by the free caloric which a body transmits to it, and not at all by that which it does not part with. You see therefore, that the temperature of bodies can be raised only by free ridiating caloric.

Caroline. I begin to understand it; but I confess that the idea of insensible heat is so new and strange to me, that it requires some time to render it familiar.

Mrs. B. Call it insensible caloric, and the difficulty will appear much less formidable. It is indeed a sort of contradiction to call it heat, when it is so situated as to be incapable of producing that sensation.

Emily. Yet is it not this modification of caloric which is called SPECIFIC HEAT?

Mrs. B. It is so; but it certainly would have been more correct to have called it *specific caloric*.

Emily. I do not understand how the term *specific* applies to this modification of caloric?

Mrs. B. It expresses the relative quantity of caloric which different bodies of the same weight and temperature are capable of containing. This modification is also frequently called *heat of capacity*, a term perhaps preferable, as it explains better its own meaning.

You now understand, I suppose, why the milk and chalk required a longer time than the lead to raise their temperature to that of the oven?

Emily. Yes: the milk and chalk having a greater

capacity for caloric than the lead, a greater proportion of that fluid became insensible in those bodies; and the more slowly, therefore, their temperature was raised.

Mrs. B. You are quite right. And could we measure the heat communicated by the oven to these three bodies, we should find, that though they have all ultimately reached the same temperature, yet they have absorbed different quantities of heat according to their respective capacities for caloric; that is to say, the milk most, the chalk next, and the lead least.

Emily. But supposing that these three bodies were made much hotter, would heat continue to become insensible in them, or is there any point beyond which the capacity of bodies for caloric is so completely filled, that their heat of temperature can alone be increased?

Mrs. B. No: there is no such point; for the capacity of bodies for caloric always increases or diminishes in proportion to their temperature; so that whenever a body is exposed to an elevation of temperature, part of the caloric it receives is detained in an insensible state, in order to fill up its increased capacity.

Emily. The more dense a body is, I suppose, the less is its capacity for caloric.

Mrs. B. That is the case with every individual body; its capacity is least when solid, greater when melted and most considerable when converted into vapour. But this does not always hold good with respect to bodies of different nature; iron, for instance, contains more specific heat than ashes, though it is certainly much more dense. This seems to show that specific heat does not merely depend upon the interstices between the particles; but, probably, also upon some peculiar power of attraction for caloric. The word capacity therefore, which is generally used, is not perhaps strictly correct; but until we are better acquainted with the nature and cause of specific heat, we cannot adopt a more appropriate term.

Emily. But, Mrs. B. it would appear to me more proper to compare bodies by *measure*, rather than by *weight*, in order to estimate their specific heat. Why,

for instance, should we not compare *pints* of milk, of chalk and of lead, rather than *pounds* of those substances; for equal weights may be composed of very different quantities?

Mrs. B. You are mistaken, my dear: equal weights must contain equal quantities of matter; and when we wish to know what is the relative quantity of caloric, which substances of various kinds are capable of containing, under the same temperature, we must compare equal weights, and not equal bulks of those substances. Bodies of the same weight may undoubtedly be of very different dimensions; but that does not change the real quantity of matter. A pound of feathers does not contain one atom more than a pound of lead.

Caroline. I have another difficulty to propose. It appears to me, that if the temperature of the three bodies in the oven did not rise equally, they would never reach the same degree; the lead would always keep its advantage over the chalk, aud milk, and would perhaps be boiling before the others had attained the temperature of the oven. I think you might as well say that, in the course of time, you and I should be of the same age?

Mrs. B. Your comparison is not correct, my dear. As soon as the lead reached the temperature of the oven, it would remain stationary; for it would then give out as much heat as it would receive. You should recollect that the exchange of radiating heat, between two bodies of equal temperature, is equal; it would be impossible, therefore, for the lead to accumulate heat after having attained the temperature of the oven; and that of the chalk and milk therefore would ultimately arrive at the same standard. Now I fear that this will not hold good with respect to our ages, and that, as long as I live, I shall never cease to keep my advantage over you.

Emily. I think that I have found a comparison for specific heat, which is very applicable. Suppose that two men of equal weight and bulk, but who required different quantities of food to satisfy their appetites, sit

down to dinner, both equally hungry; the one would consume a much greater quantity of provisions than the other, in order to be equally satisfied.

Mrs. B. Yes, that is very fair; for the quantity of food necessary to satisfy their respective appetites, varies in the same manner as the quantity of caloric requisite to raise equally the temperature of different bodies.

Emily. The thermometer, then, affords no indication of the specific heat of bodies?

Mrs. B. None at all: no more than satiety is a test of the quantity of food eaten. The thermometer, as I have repeatedly said, can be affected only by a free or radiating caloric, which alone raises the temperature of bodies.

Emily. And is there no method of measuring the comparative quantities of caloric absorbed in the oven by the lead, the chalk, and the milk?

Mrs. B. It may be done by cooling them to the same degree in an apparatus adapted to receive and measure the caloric which they give out. Thus, if you plunge them into three equal quantities of water, each at the same temperature, you will be able to judge of the relative quantity of caloric which the three bodies contained, by that, which, in cooling, they communicated to their respective portions of water; for the same quantity of caloric which they each absorbed to raise their temperature, will abandon them in lowering it; and on examining the three vessels of water, you will find the one in which you immersed the lead to be the least heated; that which contained the chalk will be the next; and that which contained the milk will be heated the most of all. The celebrated Lavoisier has invented a machine to estimate, upon this principle, the specific heat of bodies in a more perfect manner; but I cannot explain it to you, till you are acquainted with the next modification of caloric, which is called *latent heat*.

Caroline. And pray what kind of heat is that?

Mrs. B. It is so analogous to specific heat, that most chemists make no distinction between them; but Mr.

Pictet, in his Essay on fire, has so judiciously discriminated them, that I think his view of the subject may contribute to render it clearer. We therefore call *latent heat* (a name that was first used by Dr. Black) that portion of insensible caloric which is employed in changing the state of bodies; that is to say, in converting solids into liquids, or liquids into vapour. The heat which performs these changes becomes fixed in the body which it has transformed, and, as it is perfectly concealed from our senses, it has obtained the name of *latent* heat.

Caroline. I think it would be much more correct to call this modification latent caloric, instead of latent heat, since it does not excite the sensation of heat.

Mrs. B. That remark is equally applicable to both the modifications of specific and latent heat; but we must not presume (unless amongst ourselves in order to explain the subject) to alter terms which are still used by much better chemists than ourselves. And, besides, you must not suppose that the nature of heat is altered by being variously modified: for if latent heat, and specific heat, do not excite the same sensations as free caloric, it is owing to their being in a state of confinement, which prevents them from acting upon our organs; and, consequently, as soon as they are extricated from the body in which they are imprisoned, they return to their state of free caloric.

Emily. But I do not yet clearly see in what respect latent heat differs from specific heat; for they are both of them imprisoned and concealed in bodies?

Mrs. B. Specific heat is that which is employed in filling the capacity of a body for caloric, in the state in which this body actually exists; while latent heat is that which is employed only in effecting a change of state, that is, in converting bodies from a solid to a liquid, or from a liquid to an aeriform state. But I think that, in a general point of view, both these modifications might be comprehended under the name of *heat of capacity*, as in both cases the caloric is equally engaged in filling the capacities of bodies.

I shall now show you an experiment which I hope

will give you a clear idea of what is understood by latent heat.

The snow which you see in this phial, has been cooled by certain chemical means (which I cannot well explain to you at present), to 5 degrees below the freezing point, as you will find indicated by the thermometer, which is placed in it. We shall expose it to the heat of a lamp, aud you will see the thermometer gradually rise, till it reaches the freezing point——

Emily. But there the thermometer stops, Mrs. B. and yet the lamp burns just as well as before. Why is not its heat communicated to the thermometer?

Caroline. And the snow begins to melt, therefore it must be rising above the freezing point?

Mrs. B. The heat no longer affects the thermometer, because it is wholly employed in converting the ice into water. As the ice melts, the caloric becomes *latent* in the new formed liquid, and therefore cannot raise its temperature; and the thermometer will consequently remain stationary, till the whole of the ice be melted.

Caroline. Now it is all melted, and the thermometer begins to rise again.

Mrs. B. Because the conversion of the ice into water being completed, the caloric no longer becomes latent; and therefore the heat which the water now receives raises its temperature, as you find the thermometer indicates.

Emily. But I do not think that the thermometer rises so quickly in the water, as it did in the ice, previous to its beginning to melt, though the lamp burns equally well?

Mrs. B. That is owing to the different specific heat of ice and water. The capacity of water for caloric being greater than that of ice, more heat is required to raise its temperature, and therefore the thermometer rises slower in the water than in the ice.

Emily. True; you said that a solid body always increased its capacity for heat by becoming fluid; and this is an instance of it.

Mrs. B. But be careful not to confound this with latent heat.

Emily. On the contrary, I think that this example distinguishes them extremely well; for though they both go into an insensible state, yet they differ in this respect, that the specific heat fills the capacity of the body in the state in which it exists, while latent heat changes that state, and is afterwards employed in maintaining the body in its new form.

Caroline. Now, Mrs. B. the water begins to boil, and the thermometer is again stationary.

Mrs. B. Well, Caroline, it is your turn to explain the phenomenon.

Caroline. It is wonderfully curious. The caloric is now busy in changing the water into steam, in which it hides itself and becomes insensible. This is another example of latent heat, producing a change of form. At first it converted a solid body into a liquid, and now it turns the liquid into vapour!

Mrs. B. You see, my dear, how easily you have become acquainted with these modifications of insensible heat, which at first appeared so unintelligible. If, now, we were to reverse these changes, and condense the vapour into water, and the water into ice, the latent heat would re-appear entirely, in the form of free caloric.

Emily. Pray do let us see the effect of latent heat returning to its natural form.

Mrs. B. For the purpose of shewing this, we need simply conduct the vapour through this tube into this vessel of cold water, where it will part with its latent heat and return to its liquid form.

Emily. How rapidly the steam heats the water!

Mrs. B. That is because it does not merely impart its free caloric to the water, but likewise its latent heat. This method of heating liquids has been turned to advantage, in several economical establishments. At Leeds, for instance, there is a large dye-house, in which a great number of coppers are kept boiling by means of a single one, which is situated without the building, and which alone is heated by fire. The steam of this

st is conveyed through pipes into the bottom of each the other coppers, and it appears extremely singur to see all these coppers boiling, though there is not particle of fire in the place.

Caroline. That is an admirable contrivance, and I onder that it is not in common use.

Mrs. B. The steam kitchens, which are getting ito such general use, are upon the same principle. 'he steam is conveyed through a pipe in a similar ıanner, into the vessels which contain the provisions ı be dressed, where it communicates to them its latent ıloric, and returns to the state of water. Count Rumırd makes great use of this principle in many of his re-places: his grand maxim is to avoid all unnecessary 'aste of caloric, for which purpose he confines the eat in such a manner, that not a particle of it shall unecessarily escape; and while he economises the free aloric, he takes care also to turn the latent heat to adantage. It is thus that he is enabled to produce a deree of heat superior to that which is obtained in comıon fire-places, though he employs but half the quanty of fuel.

Emily. When the advantages of such contrivances re so clear and plain, I cannot understand why they re not universally used.

Mrs. B. A long time is always required before inovations, however useful, can be reconciled with the rejudices of the vulgar.

Emily. What a pity it is that there should be a rejudice against new inventions; how much more apidly the world would improve, if such useful disoveries were immediately, and universally adopted!

Mrs. B. I believe, my dear, that there are as many ovelties attempted to be introduced, the adoption of which would be prejudicial to society, as there are of hose which would be beneficial to it. The well-informd, though by no means exempt from error, have an nquestionable advantage over the illiterate, in judging what is likely or not to prove serviceable; and therefore we find the former more ready to adopt such discoveies as promise to be really advantageous, than the lat-

ter, who, having no other test of the value of a novelty but time and experience, at first oppose its introduction. The well informed are, however, frequently disappointed in their most sanguine expectations, and the prejudices of the vulgar though they often retard the progress of knowledge, yet sometimes, it must be admitted, prevent the propagation of error.—But we are deviating from our subject. We have converted steam into water, and are now to change water into ice, in order to render the latent heat sensible, as it escapes from the water on its becoming solid. For this purpose we must produce a degree of cold that will make water freeze.

Caroline. That must be very difficult to accomplish in this warm room.

Mrs. B. Not so much so as you think. There are certain chemical mixtures which produce a rapid change from the solid to the fluid state, or the reverse, in the substances combined, in consequence of which change latent heat is either extricated or absorbed.

Emily. I do not quite understand you.

Mrs. B. This snow and salt, which you see me mix together, are melting rapidly; heat, therefore must be absorbed by the mixture, and cold produced.

Caroline. It feels even colder than ice, and yet the snow is melted. This is very extraordinary.

Mrs. B. The cause of the intense cold of the mixture is to be attributed to the change from a solid to a fluid state. The union of the snow and salt produces a new arrangement of their particles, in consequence of which they become liquid, and the quantity of caloric required to effect this change is seized upon by the mixture wherever it can be obtained. This eagerness of the mixture for caloric, during its liquefaction, is such, that it converts part of its own free caloric into latent heat, and it is thus that its temperature is lowered.

Emily. Whatever you put into this mixture therefore, would freeze?

Mrs. B. Yes; at least any fluid that is susceptible of freezing at that temperature; for the exchange of radient heat would always be in favour of the cold mix-

ure, until an equilibrium of temperature was established; therefore unless the body immersed contained more free caloric than would become latent in the mixture during its conversion into a liquid, the former must ultimately give out its latent heat till it cools down to the temperature of the latter. I have prepared this mixture of salt and snow for the purpose of freezing the water from which you are desirous of seeing the latent heat escape. I have put a thermometer in the glass of water that is to be frozen, in order that you may observe how it cools——

Caroline. The thermometer decends, but the heat which the water is now losing, is its *free*, not its *latent* heat?

Mrs. B. Certainly; it does not part with its latent heat till it changes its state and is converted into ice.

Emily. But here is a very extraordinary circumstance! The thermometer is fallen below the freezing point, and yet the water is not frozen.

Mrs. B. That is always the case previous to the freezing of water when it is in a state of rest. Now it begins to congeal, and you may observe that the thermometer again rises to the freezing point.

Caroline. It appears to me very strange that the thermometer should rise the very moment that the water freezes; for it seems to imply that the water was colder before it froze than when in the act of freezing.

Mrs. B. It is so; and after our long dissertation on this circumstance, I did not think that it would appear so surprising to you. Reflect a little, and I think you will discover the reason of it.

Caroline. It must be, no doubt, the extrication of latent heat, at the instant the water freezes, that raises the temperature.

Mrs. B. Certainly; and if you now examine the thermometer, you will find that its rise was but temporary, and lasted only during the disengagement of the latent heat; it has since fallen and will continue to fall till the ice and mixture are of an equal temperature.

Emily. And can you show us any experiments in which liquids, by being mixed, become solid, and disengage latent heat?

Mrs. B. I could show you several; but you are not yet sufficiently advanced to understand them well. I shall, however, try one which will afford you a striking instance of the fact. The fluid which you see in this phial consists of a quantity of a certain salt called *muriat of lime*, dissolved in water. Now if I pour into it a few drops of this other fluid, called *sulphuric acid*, the whole, or very nearly the whole, will be instantaneously converted into a solid mass.

Emily. How white it turns! I feel the latent heat escaping, for the bottle is warm, and the fluid is changed to a solid white substance like chalk!

Caroline. This is indeed the most curious experiment we have seen yet. But pray what is that white vapour that ascends from the mixture?

Mrs. B. You are not yet enough of a chemist to understand that. But take care, Caroline, do not approach too near it, for it smells extremely strong.

The mixture of spirit of wine and water affords another striking example of the extrication of latent heat. The particles of these liquids, by penetrating each other, change their arrangement, so as to become more dense, and (if I may use the expression), less fluid, in consequence of which they part with a quantity of latent heat.

Sulphuric acid and water produce the same effect, and even in a much greater degree. We shall try both these experiments, and you will feel how much heat which was in a latent state, is set at liberty.—Now each of you take hold of one of these glasses——

Caroline. I cannot hold mine; I am sure it is as hot as boiling water.

Mrs. B. Your glass, which contains the sulphuric acid and water, is indeed, of as high a temperature as boiling water; but you do not find yours so hot, Emily!

Emily. Not quite. But why are not these liquids converted into solids by the extrication of their latent heat?

Mrs. B. Because they part only with a portion of that heat, and therefore they suffer only a diminution of their liquidity.

Emily. Yet they appear as perfectly liquid as they had before they were mixed.

Mrs. B. They are however considerably condensed. I shall repeat the experiment in a graduated tube, and you will see that the two liquids, when mixed, occupy less space than they did separately. This tube is graduated by cubit inches, and this little measure contains exactly one cubit inch; therefore, if I fill it twice, and pour its contents into the tube, they should fill it up to the second mark.

Caroline. And so they do exactly.

Mrs. B. Because I put two measures of the same liquid into the tube; but we shall now try it with one of water and one of sulphuric acid; observe the difference—

Emily. The two measures, this time, evidently take up less space, though the fluid does not appear to have suffered any change in its liquidity.

Mrs. B. The two liquids, however, have undergone some degree of condensation from the new arrangement of their particles; they have penetrated each other, so as to form a closer substance, and have thus, as it were, squeezed out a portion of their latent heat. But this change of state is certainly much less striking, and less complete, than when liquids are converted into solids.

The slakeing of lime is another curious instance of the extrication of latent heat. Have you never observed how quick-lime smokes when water is poured upon it, and how much heat it produces?

Caroline. Yes; but I do not understand what change of state takes place in the lime that occasions its giving out latent heat; for the quick-lime, which is solid, is (if I recollect right) reduced to powder by this operation, and is therefore rather expanded than condensed.

Mrs. B. It is from the water, not the lime, that the latent heat is set free. The water incorporates with, and becomes solid in the lime; in consequence

of which the heat, which kept it in a liquid stat
disengaged and escapes into a sensible form.

Caroline. I always thought that the heat origi
in the lime. It seems very strange that water
cold water too, should contain so much heat.

Emily. After this extrication of caloric, the
must exist in a state of ice in the lime, since it
with the heat which kept it liquid?

Mrs. B. It cannot properly be called ice, sin
implies a degree of cold, at least equal to the fre
point. Yet as water, in combining with lime,
out more heat than in freezing, it must be
state of still greater solidity in the lime, than it is
form of ice; and you may have observed that it
not moisten or liquefy the lime in the smallest d

Emily. But, Mrs. B. the smoke that rises is
if it was only pure caloric which escaped, we
feel, but could not see it.

Mrs. B. This white vapour is formed by s
the particles of lime, in a state of fine dust,
are carried off by the caloric.

Emily. In all changes of state, then, a body
absorbs or disengages latent heat?

Mrs. B. You cannot exactly say *absorbs* late
as the heat becomes latent only on being confi
the body; but you may say that bodies, in passin
a solid to a liquid form, or from the liquid state
of vapour, absorbs heat; and that when the
takes place heat is disengaged.* We have see
wise, that a body may part with some of its late
without completely changing its form, as was t
with the mixtures of sulphuric acid and wat
spirit of wine and water; but here you must c
that the condensation which forces out a po
their latent heat, is occasioned by a new arran
of the particles, produced by mixing the liquid
therefore undergo a change of state, though
sensible difference takes place in their form.

* This rule, if not universal, admits of very few exc

Caroline. All solid bodies, I suppose, must have parted with the whole of their latent heat?

Mrs. B. We cannot precisely say that; for solid bodies are most of them susceptible of being brought to different degrees of density, during which operation a quantity of heat is disengaged; as it happens in the hammering of metals, the boring of cannon, and in general whenever bodies are exposed to considerable friction or violent pressure.

It has been much disputed, however, to what modification of heat caloric thus extricated belongs, though in general it has been considered as latent heat; but it does not seem strictly entitled to that name, as its extrication produces no other change in the body than an increase of density.

Emily. And may not the same objection be made to the heat extricated from the mixtures we have just witnessed? for the only alteration that is produced by it is a greater density.

Mrs. B. But I observed to you, that the density was produced by a new arrangement of the particles, owing to the mixing of two different substances; this cannot be the case, when heat is extricated from solid bodies by mere mechanical force, such as hammering metals; no foreign particles are introduced, and except a closer union, no change of arrangement can take place. The caloric, thus extricated, seems therefore to have a still more dubious title to the modification of latent heat, than that produced by mixtures. I know no other way of settling this difficulty than by calling them both heat of capacity, a title to which we have agreed that specific heat, and latent heat, have an equal claim.

Emily. We can now, I think, account for the ether boiling, and the water freezing in vacuo, at the same temperature.

Mrs. B. Let me hear how you explain it?

Emily. The latent heat, which the water gave out in freezing, was immediately absorbed by the ether, during its conversion into vapour; and therefore, from

a latent state in one liquid, it passed into a late in the other.

Mrs. B. But this only partly accounts for periment; it remains to be explained why the rature of the ether, while in a state of ebull brought down to the freezing temperature of th It is because the ether, during its evaporation, its own temperature, in the same proportion as the water, by converting its free caloric into late so that, though one liquid boils, and the other their temperatures remain in a state of equilibr

Having advanced so far on the subject of may now give you an account of the calorimeter strument invented by Lavoisier, upon the pr just explained, for the purpose of estimating cific heat of bodies. It consists of a vessel, tl surface of which is lined with ice, so as to for of hollow globe of ice, in the midst of which tl whose specific heat is to be ascertained, is place ice absorbs caloric from this body, till it has it down to the freezing point: this caloric con to water a certain portion of the ice which r through an aperture at the bottom of the m and the quantity of ice changed to water is a the quantity of caloric which the body has gi in descending from a certain temperature to th ing point.

Caroline. In this apparatus, I suppose, th chalk, and lead, would melt different quantities in proportion to their different capacities for calo

Mrs. B. Certainly; and thence we are abl certain, with precision, their respective capac heat. But the calorimeter affords us no mo of the absolute quantity of heat contained in than the thermometer; for though by means c extricate both the free and confined caloric, yet tricate them only to a certain degree, which freezing point: and we know not how much th tain of either below that point.

Emily. According to this theory of latent appears to me the weather should be warm v

freezes, and cold in a thaw: for latent heat is liberated from every substance that freezes, and such a large supply of heat must warm the atmosphere; whilst, during a thaw, that very quantity of free heat must be taken from the atmosphere, and return to a latent state in the bodies which it thaws.

Mrs. B. Your observation is very natural; but consider, that in a frost the atmosphere is so much colder than the earth, that all the caloric which it takes from the freezing bodies is insufficient to raise its temperature above the freezing point; otherwise the frost must cease. But if the quantity of latent heat extricated does not destroy the frost, it serves to moderate the suddenness of the change of temperature of the atmosphere, at the commencement both of a frost, and of a thaw. In the first instance, its extrication diminishes the severity of the cold; and, in the latter, its absorption moderates the warmth occasioned by a thaw: it even sometimes produces a discernible chill, at the breaking up of a frost.

Caroline. But what are the general causes that produce those sudden changes in the weather, especially from hot to cold, which we often experience?

Mrs. B. This question would lead us into meteorological discussions, to which I am by no means competent. One circumstance, however, we can easily understand. When the air has passed over cold countries, it will probably arrive here, at a temperature much below our own, and then it must absorb heat from every object it meets with which will produce a general fall of temperature.

But I think we have now sufficiently dwelt on the subject of latent heat; we may therefore proceed to the last modification, which is CHEMICAL HEAT. In this state we consider caloric as one of the constituent parts of bodies. Like any other substance, it is subject to the attraction of composition, and is thus capable of being chemically combined.

Emily. In this case, then, it neither affects the thermometer, nor the calorimeter, since principles united

by the attraction of composition can be separated only by the decomposition of a body.

Mrs. B. You are perfectly right. We may consider *free caloric* as moving constantly through the integrant particles of a body; *specific* and *latent heat*, as lodging between them, and being there detained by a mere mechanical union; but it is *chemical heat* alone that actually *combines*, in consequence of a true chemical affinity, with the constituent particles of bodies; and this union cannot be dissolved without a decomposition produced by superior attractions.

Caroline. But if this kind of heat is so perfectly concealed in the body, pray how is it known to exist?

Mrs. B. By being freed from its imprisonment; for when the body in which it exists is decomposed, it then returns to the state of free caloric. This caloric, however, seldom shews itself entirely, as part of it generally enters into new combinations with some of the constituent parts of the decomposed body, and is thus again concealed under the form of latent heat.

But it will be better to defer saying any thing further of this modification of heat at present. When we come to analyse compound bodies, and resolve them into their constiuent parts, we shall have many opportunities of becoming better acquainted with it.

Caroline. Caloric appears to me a most wonderful element: but I cannot reconcile myself to the idea of its being a substance; for it seems to be constantly acting in opposition, both to the attraction of aggregation and the laws of gravity; and yet you decidedly class it amongst the simple bodies.

Mrs. B. You are not at all singular in the doubts you entertain, my dear, on this point; for although caloric is now generally believed to be a real substance, yet there are certainly some strong circumstances which seem to militate against this doctrine.

Caroline. But do *you*, Mrs. B. believe it to be a substance?

Mrs. B. Yes, I do: but I am inclined to think, that its levity is, in all probability, only relative, like

that of vapour which ascends through the heavier medium, air.

Caroline. If that be the case, it would not ascend in a vacuum.

Mrs. B. In an absolute vacuum, perhaps, it would not. But as the most complete vacuum we can obtain is never perfect, we may always imagine the existence of some unknown invisible fluid, which however light and subtile, may be heavier than caloric, and will gravitate in it. The fact has not, I believe, been yet determined by very decisive experiments; but it appears from some made by Professor Pictet, mentioned in his 'Essay on Fire,' that heat has a tendency to ascend in the most complete vacuum which we are able to obtain.

Emily. But if there exists such a subtle fluid as you imagine, do you not think that chemists would have discovered it by some of its properties?

Mrs. B. It has been conjectured that light might be such a fluid; but I confess that I do not think it probable: for as it appears by Dr. Herschell's experiment that heat is less refrangible than light, I should be rather inclined to think it the heavier of the two. But, while you have so many well ascertained facts to learn, I shall not perplex you with conjectures. We have dwelt on the subject of caloric much longer than I intended, and I fear you will find it difficult to remember so long a lesson. At our next meeting we shall examine the nature of oxygen and nitrogen, two substances with which you must now be made acquainted.

Conversation V.

On Oxygen and Nitrogen.

Mrs. B.

TO-DAY we shall examine the chemical properties of the ATMOSPHERE.

Caroline. I thought you said that we were to learn the nature of OXYGEN and NITROGEN, which come next in our table of simple bodies?

Mrs. B. And so you shall: the atmosphere is composed of these two principles; we shall therefore analyse it, and consider its component parts separately.

Emily. I always thought that the atmosphere had been a very complicated fluid, composed of all the variety of exhalations from the earth.

Mrs. B. In a general point of view, it may be said to consist of all the substances capable of existing, in an aeriform state, at the common temperature of our globe. But, laying aside these heterogenous and accidental substances (which rather float in the atmosphere than form any of its component parts), it consists of an elastic fluid called ATMOSPHERICAL AIR, which is composed of two gasses, known by the names of OXYGEN GAS and NITROGEN or AZOTIC GAS.

Emily. Pray what is a gas?

Mrs. B. The name of *gas* is given to any aeriform fluid, which consists of some substances chemically combined with caloric, and capable of existing constantly in an aeriform state, under the pressure, and at the temperature of the atmosphere. Every individual gas is therefore composed of two parts: 1st, the particular substance that is converted into a gas, by caloric; this is called the *basis* of the gas, as it is from it that the gas derives all its specific and characteristic properties: and 2dly, the caloric, which, by its chemical combination with the basis, constitutes it a gas, or permanently elastic fluid.

Emily. When you speak then of the simple substances, oxygen and nitrogen, you mean to express, those substances which are the basis of the two gasses, independently of caloric?

Mrs. B. Yes, in strict propriety; and they should be called gasses, only when brought, by their combination with caloric, to an aeriform state.

Caroline. Is not water, or any other substance, when evaporated by heat, called also a gas?

Mrs. B. No, my dear; vapour is, indeed, an elastic fluid, and bears so strong a resemblance to a gas, that there is some danger of confounding them; there are however, several points in which they essentially differ, and by which you may always distinguish them.

Vapour is nothing more than the solution, or mechanical division, of any substance whatever in caloric. The caloric, in this case, becomes *latent* in the vapour; but its union with it is very slight, and as we have seen in a variety of instances, it is necessary only to lower the temperature in order to separate them. But, to form a gas or *permanently* elastic fluid, a chemical combination must take place between the caloric and the substance, at the time of its being converted into a gaseous state; it is necessary therefore, that there should be an affinity between them, and hence their combination cannot be destroyed by a mere change of temperature, or by any chemical agents, except such as have a stronger affinity, for either of the constituents of the gas, and by that means effect its decomposition.

Caroline. Indeed, I ought not to have forgotten that caloric, in vapour, is only *latent*, and not chemically combined. But pray, Mrs. B. what kinds of substances are oxygen and nitrogen, when not in a gaseous state?

Mrs. B. We have never been able to obtain these substances in their pure simple state, because we cannot separate them entirely either from caloric or from the other bodies with which we find them united; it is therefore only by their effects in combining with other substances that we are acquainted with them

Caroline. How much more satisfactory it would be if we could see them!

Emily. In what proportions are they combined in the atmosphere?

Mrs. B. The oxygen gas constitutes about one-fourth, and the nitrogen gas three-fourths. When separated, they are found to possess qualities totally different from each other. Pure oxygen gas is essential both to respiration and combustion, while neither of these processes can be performed in nitrogen gas.

Mrs. B. Yes; and the heat and light are produced by the caloric of the oxygen gas, which being set at liberty by the oxygen uniting with the wood, appears in its sensible form.

Caroline. You astonish me! Is it possible that the heat of a burning body should be produced by the atmosphere, and not by the body itself.

Mrs. B. It is not precisely ascertained whether any portion of the caloric is furnished by the combustible body; but there is no doubt that by far the most considerable part of it is disengaged from the oxygen gas, when its basis combines with the combustible body.

Emily. I have not yet met with any thing in chemistry that has surprised or delighted me so much as this explanation of combustion. I was at first wondering what connection there could be between the affinity of a body for oxygen and its combustibility; but I think I understand it now perfectly.

Mrs. B. Combustion then, you see, is nothing more than the rapid absorption of the basis of oxygen gas, by a combustible body, attended by the disengagement of the light and heat, which were combined with the oxygen when in its gaseous state.

Emily. But are there no combustible bodies whose attraction for oxygen is so strong, that they will overcome the resistance of the attraction of aggregation, without the application of heat?

Caroline. That cannot be; otherwise we should see bodies burning spontaneously.

Mrs. B. This indeed, sometimes happens, (and for the very reason which Emily assigns), as I shall show you at some future time. But in general, all the combustions that could occur spontaneously, at the temperature of the atmosphere, have already taken place; therefore new combustions cannot happen without raising the temperature of the body. Some bodies, however, will burn at a much lower temperature than others.

Emily. The elevation of temperature, required to make a body burn, must, I suppose depend entirely upon the force of aggregation to be overcome?

Mrs. B. That is one point; but you mu recollect, that there must be a stronger affinit the body and oxygen, than between the latte caloric; otherwise the oxygen will not quit its form to combine with the body. It is this de affinity for oxygen that constitutes a combustible body. The earths and alkalies have no such affinity for oxygen, and are therefore incombustible. But in order to make a combustible body burn, you see that it is necessary to give the first impulse to combustion by the approach of a hot or burning body, from which it may obtain a sufficient quantity of caloric to raise its temperature.

Caroline. But the common way of burning a body is not merely to approach it to one already on fire, but rather to put the one in actual contact with the other, as when I burn this piece of paper by holding it in the flame of the fire.

Mrs. B. The closer it is in contact with the source of caloric, the sooner will its temperature be raised to the degree necessary for it to burn. If you hold it near the fire, the same effect will be produced; but more time will be required, as you found to be the case with the piece of stick.

Emily. But why is it not necessary to continue applying caloric throughout the process of combustion, in order to prevent the attraction of aggregation from recovering its ground and impeding the absorption of the oxygen?

Mrs. B. The caloric, which is gradually disengaged, by the decomposition of the oxygen gas, during combustion, keeps up the temperature of the burning body; so that when once combustion has begun, no further application of caloric is required.

Caroline. Since I have learnt this wonderful theory of combustion, I cannot take my eyes from the fire; and I can scarcely conceive that the heat and light which I always supposed to proceed from the coals, are really produced by the atmosphere, and that the coals are only the instruments by which the decomposition of the oxygen gas is effected.

Caroline. But since nitrogen gas is unfit for respiration, how does it happen that the three fourths of this gas, which enter into the composition of the atmosphere, are not a great impediment to breathing?

Mrs. B. We should breath more freely than our lungs could bear, if we respired oxygen gas alone. The nitrogen is no impediment either to respiration, or cumbustion; it appears to be merely passive in those functions; but it serves as it were, to dilute and weaken the oxygen which we breathe, as you would weaken the wine that you drink, by diluting it with water.

Emily. And by what means can the two gasses, which compose the atmospheric air, be separated?

Mrs. B. There are many ways of analysing the atmosphere; the two gasses can be separated first by combustion.

Emily. How is it possible that combustion should separate them?

Mrs. B. I must first tell you, that all bodies, excepting the earths and alkalies, have so strong an affinity for oxygen, that they will, in certain circumstances, attract and absorb it from the atmosphere; in this case the nitrogen gas remains alone, and we thus obtain it in its simple gaseous state.

Caroline. I do not understand how a gas can be absorbed?

Mrs. B. The gas is not absorbed, but decomposed; and it is oxygen only, that is to say, the basis of the gas, which is absorbed.

Caroline. What then becomes of the caloric of the oxygen gas, when it is deprived of its basis?

Mrs. B. We shall make this piece of dry wood absorb oxygen from the atmosphere, and you will see what becomes of the caloric.

Caroline. You are joking, Mrs. B. you do not mean to decompose the atmosphere with a piece of stick?

Mrs. B. Not the whole body of the atmosphere, certainly; but if we can make this stick absorb any quantity of oxygen from it, will not a proportional quantity of atmospherical air be decomposed?

Caroline. Undoubtedly; but if wood has so strong an affinity for oxygen, as to attract it from the caloric with which it is combined in the atmosphere, why does it not decompose the atmosphere spontaneously?

Mrs. B. Because the attraction of aggregation of the particles of the wood, is an obstacle to their combination with the oxygen: for you know that the oxygen must penetrate the wood in order to combine with its particles, and forcibly separate them in direct opposition to the attraction of aggregation.

Emily. Just as caloric penetrates bodies?

Mrs. B. Yes; but caloric being a much more subtile fluid than oxygen, can penetrate substances much more easily.

Caroline. But if the attraction of cohesion between the particles of a body, counteracts its affinity for oxygen, I do not see how that body can decompose the atmosphere?

Mrs. B. That is now the difficulty which we have to remove with regard to the piece of wood.—Can you think of no method of diminishing the attraction of cohesion?

Caroline. Heating the wood, I should think, might answer the purpose; for the caloric would separate the particles, and make room for the oxygen.

Mrs. B. Well, we shall try your method; hold the stick close to the fire—closer still, that it may imbibe the caloric plentifully; otherwise the attraction of cohesion between its particles will not be sufficiently overcome—

Caroline. It has actually taken fire, and yet I did not let it touch the coals; but I held it so very close, that I suppose it caught fire merely from the intensity of the heat.

Mrs. B. Or you might say, in other words, that the heat so far overcame the attraction of cohesion of the wood, that it was enabled to absorb oxygen very rapidly from the atmosphere.

Emily. Does the wood absorb oxygen while it is burning?

gaseous state ; it is a constituent part of a vast number of bodies, both solid and liquid, in which it exists in a much denser state than in the atmosphere ; and from these bodies it may be obtained without any disengagement of caloric. It may likewise, in some cases, be absorbed from the atmosphere without any sensible production of light and heat ; for if the process be slow, the caloric is disengaged in small quantities, and so gradually, that it is not capable of producing either light or heat. In this case, the absorption of oxygen is called *oxygenation* or *oxydation*, instead of *combustion*, as the disengagement of sensible light and heat is essential to the latter.

Emily. I wonder that metals can unite with oxygen; for, as they are very dense, their attraction of aggregation must be very great, and I should have thought that oxygen could never have penetrated such bodies.

Mrs. B. Their strong attraction for oxygen counterbalances this obstacle. Most metals, however, require to be made red hot before they are capable of attracting oxygen in any considerable quantity. By this process they lose most of their metallic properties, and fall into a kind of powder, formerly called *calx*, but now much more properly termed an *oxyd ;* thus we have *oxyd of lead*, *oxyd of iron*, &c.

Caroline. The word oxyd, then, simply means a metal combined with oxygen ?

Mrs. B. Yes ; but the term is not confined to metals, though chiefly applied to them. Any body whatever, that has combined with a certain quantity of oxygen, either by means of oxydation or combustion, is called an *oxyd*, and is said to be *oxydated* or *oxygenated*.

This black powder is an oxyd of manganese, a metal which has so strong an attraction for oxygen, that it absorbs that substance from the atmosphere at any known temperature : it is therefore never found in its metallic form, but always in that of an oxyd, in which state, you see, it has very little of the appearance of a metal. It is now heavier than it was before oxydation, in consequence of the additional weight of the oxygen with which it has combined.

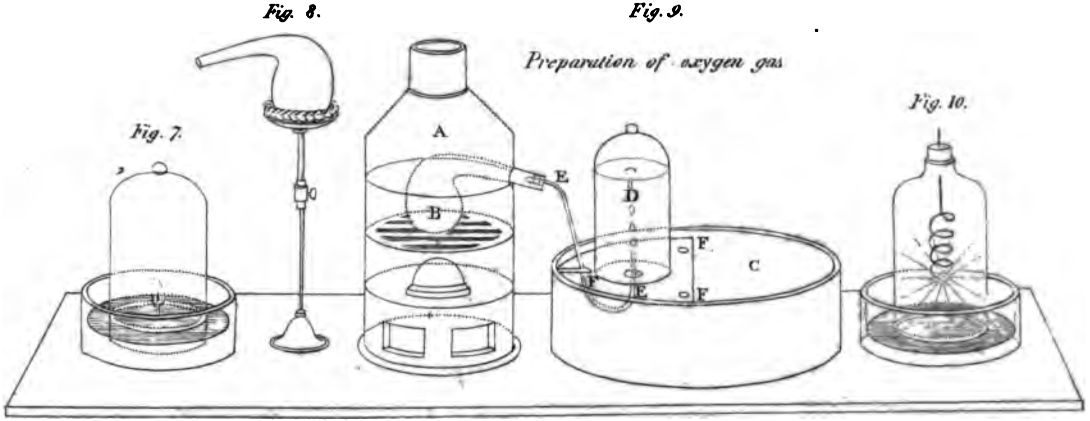


Fig. 7.
Fig. 8.
Fig. 9.
Preparation of oxygen gas
Fig. 10.
A
B
C
D
E
E
F
F
F

aroline. I am very glad to hear that; for I confess uld not help having some doubts whether oxygen really a substance, as it is not to be obtained in a ɔle and palpable state: but its weight is, I think, cisive proof of its being really a body.

Mrs. B. It is easy to estimate its weight, by separ- g it from the manganese, and finding how much atter has lost.

mily. But if you can take the oxygen from the al, shall we not then have it in its palpable simple ?

Mrs. B. No; for I can only separate the oxygen the manganese, by presenting to it some other for which it has a greater affinity than for the ganese. Caloric possesses such a superior affinity oxygen, provided the temperature of the metal sufficiently raised; if, therefore, I heat this oxyd nanganese to a certain degree, the caloric will com- with the oxygen, and carry it off in the form of

mily. But you said just now, that manganese ld attract oxygen from the atmosphere in which s combined with caloric; how, therefore, can the gen have a superior affinity for caloric, since it ndons the latter to combine with the manganese?

Mrs. B. I give you credit for this objection, Emily; the only answer I can make to it is, that the mutu- finities of metals for oxygen and of oxygen for ca- , vary at different temperatures; a certain degree heat will, therefore, dispose a metal to combine oxygen, whilst on the contrary, the former will compelled to part with the latter when the tempera- is further increased. I have put some oxyd of ganese into a retort, which is an earthen vessel with nt neck, such as you see here (*Plate* V. *Fig.* 8.)

PLATE V.

g. 7. Combustion of a taper under a receiver. Fig. 8. A re- on a stand. Fig. 9. A furnace. B. Earthen retort in the ace. C. water bath. D. Receiver. E E. Tube conveying gas from the retort through the water into the receiver. F. *Shelf perforated on which the receiver stands.* Fig. 10. *bustion of iron wire in oxygen gas.*

—The retort containing the manganese you cannot see, as I have enclosed it in this furnace, where it is now red hot. But in order to make you sensible of the escape of the gas, which is itself invisible, I have connected the neck of the retort with this bent tube, the extremity of which is immersed in this vessel of water (*Plate* V, *Fig.* 9.)—Do you see the bubbles of air rise through the water?

Caroline. Perfectly. This, then is pure oxygen gas; what a pity it should be lost! Could you not preserve it?

Mrs. B. We shall collect it in this receiver.—For this purpose, you observe, I first fill it with water, in order to exclude the atmospherical air; and then place it over the bubbles that issue from the retort, so as to make them rise through the water to the upper part of the receiver.

Emily. The bubbles of oxygen gas rise, I suppose, from their specific levity?

Mrs. B. Yes; for though oxygen forms rather a heavy gas, it is light compared to water. You see how it gradually displaces the water from the receiver. It is now full of gas, and I may leave it inverted in water on this shelf, where I can keep the gas as long as I choose for future experiments. This apparatus (which is indispensable in all experiments in which gasses are concerned) is called a water-bath.

Caroline. It is a very clever contrivance, indeed; it is equally simple and useful. How convenient the shelf is for the receiver to rest upon under water, and the holes in it for the gas to pass into the receiver! I long to make some experiments with this apparatus.

Mrs. B. I shall try your skill that way, when you have a little more experience. I am now going to show you an experiment, which proves, in a very striking manner, how essential oxygen is to combustion. You will see that iron itself will burn in this gas, in the most rapid and brilliant manner.

Emily. Really! I did not know that it was possible to burn iron.

Mrs. B. Iron is eminently combustible in pure oxy-

gen gas, and what will surprise you still more, it can be set on fire without any very great rise of temperature. You see this spiral iron wire—I fasten it at one end to this cork, which is made to fit an opening at the top of the glass receiver (*Plate* V. *Fig*. 10.)—

Emily. I see the opening in the receiver; but it is carefully closed by a ground glass stopper.

Mrs. B. That is in order to prevent the gas from escaping; but I shall take out the stopper, and put in the cork, to which the wire hangs.—Now I mean to burn this wire in the oxygen gas, but I must fix a small piece of lighted tinder to the extremity of it, in order to give the first impulse to combustion; for however powerful oxygen is in promoting combustion, you must recollect that it cannot take place without a certain elevation of temperature. I shall now introduce the wire into the receiver, by quickly changing the stoppers.

Caroline. Is there no danger of the gas escaping while you change the stoppers?

Mrs. B. Oxygen gas is a little heavier than atmospherical air, therefore it will not mix with it very rapidly; and if I do not leave the opening uncovered we shall not lose any——

Caroline. Oh, what a brilliant and beautiful flame!

Emily. It is as white, and dazzling as the sun!—Now a piece of the melted wire drops to the bottom: I fear it is extinguished; but no, it burns again as bright as ever.

Mrs. B. It will burn till the wire is entirely consumed, provided the oxygen be not first expended; for you know it can burn only while there is oxygen to combine with it.

Caroline. I never saw a more beautiful light. My eyes can hardly bear it! How astonishing to think that all this caloric was contained in the small quantity of gas that was enclosed in the receiver; and that, without producing any sensible heat!

Mrs. B. The caloric of the oxygen gas could not produce any sensible heat before the combustion took place, because it was not in a free state. You can tell

[illegible]. I begin [illegible] what modification of heat this caloric is to be referred?

Caroline. Since it is combined with the basis of the gas, it must be chemical heat.

Emily. Chemical heat is then extricated in all combustions?

Mrs. B. Certainly. By the decomposition of the gas, the caloric returns to its free state, and thus produces a quantity of sensible heat, proportioned to the rapidity of that decomposition.

Caroline. How wonderfully quick combustion goes on in pure oxygen gas! But pray are these drops of burnt iron as heavy as the wire was before?

Mrs. B. They are even heavier; for the iron in burning, has acquired exactly the weight of the oxygen gas which has disappeared, and is now combined with it. It has become an oxyd of iron.

Caroline. I do not know what you mean by saying that the oxygen has disappeared, Mrs. B. for it was always invisible.

Mrs. B. True, my dear; the expression was incorrect. But though you could not see the oxygen gas, I believe you had no doubt of its presence, as the effect it produced on the wire was sufficiently evident.

Caroline. Yes, indeed; yet you know it was the caloric of the gas, and not the oxygen gas itself, that dazzled us so much.

Mrs. B. You are not quite correct in your turn, in saying the caloric dazzled you; for caloric is invisible; it affects only the sense of feeling; it was the light which dazzled you.

Caroline. True; but light and caloric are such constant companions, that it is difficult to separate them, even in idea.

Mrs. B. The easier it is to confound them the more careful you should be in making the distinction.

Caroline. But why has the water now risen, and filled part of the receiver?

Mrs. B. Indeed, Caroline, I did not think you would

have asked such a question! I am sure, Emily, you can answer it.

Emily. Let me reflect . . . . The oxygen has combined with the wire; the caloric has escaped; consequently nothing can remain in the receiver, and the water will rise to fill the vacuum.

Caroline. I wonder that I did not think of that. I wish that we had weighed the wire and the oxygen gas before combustion; we might then have found whether the weight of the oxyd was equal to that of both.

Mrs. B. You might try the experiment if you particularly wished it; but I can assure you, that, if accurately performed, it never fails to show that the additional weight of the oxyd is precisely equal to that of the oxygen absorbed, whether the process has been a real cumbustion, or a simple oxygenation.

Caroline. But this cannot be the case with combustions in general, for when any substance is burnt in the common air, so far from increasing in weight, it is evidently diminished, and sometimes entirely consumed.

Mrs. B. But what do you mean by the expression *consumed?* You cannot suppose that the smallest particle of any substance in nature can be actually destroyed. A compound body is decomposed by combustion; some of its constituent parts fly off in a gaseous form, while others remain in a concrete state; the former are called the *volatile*, the latter the *fixed products* of combustion. But if we collect the whole of them, we shall always find that they exceed the weight of the combustible body, by that of the oxygen which has combined with them during combustion.

Emily. In the combustion of a coal fire, then, I suppose that the ashes are what would be called the fixed product? and the smoke the volatile product?

Mrs. B. Yet when the fire burns best, and the quantity of volatile products should be the greatest, there is no smoke; how can you account for that?

Emily. Indeed I cannot; therefore I suppose that I was not right in my conjecture.

Mrs. B. Not quite: ashes as you supposed, are a fixed product of combustion; but smoke, properly

speaking, is not one of the volatile products, as it consists of some minute undecomposed particles of the coals that are carried off by the coloric without being burnt, and are either deposited in the form of soot, or dispersed by the wind. Smoke therefore, ultimately becomes one of the *fixed* products of combustion. And you may easily conceive that the stronger the fire is, the less smoke it produces, because the fewer particles escape combustion. On this principle depends the invention of Argand's patent lamps; a current of air is made to pass through the cylindrical wick of the lamp, by which means it is so plentifully supplied with oxygen, that not a particle of oil escapes combustion, nor is an atom of smoke produced.

Emily. But what then are the volatile products of combustion?

Mrs. B Various new compounds, with which you are not yet acquainted, and which being converted by caloric, either into vapour, or gas, are invisible; but they can be collected, and we shall examine them, at some future period.

Caroline. There are then other gasses, besides the oxygen and nitrogen gasses.

Mrs. B. Yes, several: any substance that has a sufficient affinity for caloric to combine with it, and assume and maintain the form of an elastic fluid at the temperature of the atmosphere, is capable of being converted into a gas. We shall examine the several gasses in their respective places; but we must now confine our attention to those that compose the atmosphere.

I shall show you another method of decomposing the atmosphere, which is very simple. In breathing we retain a portion of the oxygen, and expire the nitrogen gas; so that if we breathe in a closed vessel, for a certain length of time, the air within it will be deprived of its oxygen gas. Which of you will make the experiment?

Caroline. I should be very glad to try it.

Mrs. B. Very well; breathe several times through this glass tube into the receiver with which it is connected, until you feel that your breath is exhausted—

Caroline. I am quite out of breath already!

Mrs. B. Now let us try the gas with a lighted taper.

Emily. It is very pure nitrogen gas, for the taper is immediately extinguished.

Mrs. B. That is not a proof of its being pure, but only of the absence of oxygen, as it is that principle alone that can produce combustion, every other gas being absolutely incapable of it.

Emily. In the methods which you have shown us, for decomposing the atmosphere, the oxygen always abandons the nitrogen; but is there no way of taking the nitrogen from the oxygen, so as to obtain the latter pure from the atmosphere?

Mrs. B. You must observe, that whenever oxygen is taken from the atmosphere, it is by decomposing the oxygen gas: we cannot do the same with the nitrogen gas, because nitrogen has a stronger affinity for caloric than for any other known principle: it appears impossible therefore to separate it from the atmosphere by the power of affinities. But if we cannot obtain the oxygen gas by this means, in its separate state, we have no difficulty (as you have seen) to procure it in its gaseous form, by taking it from those substances that have absorbed it from the atmosphere. This is done by combining the oxygen, at a high temperature, with caloric, as we did with the oxyd of manganese.

Emily. Can atmospherical air be recomposed, by mixing due proportions of oxygen and nitrogen gasses.

Mrs B. Yes: if about one-fourth of oxygen gas be mixed with three-fourths of nitrogen gas, atmospherical air is produced.

Emily. The air then must be an oxyd of nitrogen?

Mrs. B. No, my dear; for there must be a chemical combination between oxygen and nitrogen in order to produce an oxyd; whilst in the atmosphere these two substances are separately combined with caloric, forming two distinct gasses, which are simply mixed in the formation of the atmosphere.*

* This, at least, seems to be the prevailing opinion. Yet it has been questioned by some chemists, particularly of late, whether the union of oxygen and nitrogen in the atmosphere be not a true chemical combination.

I shall say nothing more of oxygen and nit
sent as we shall continually have occasio
them in our future conversations. They a
abundant in nature; nitrogen is the most
the atmosphere, and exists also in all ani
ces; oxygen forms a constituent part, bo
and vegetable kingdoms, from which it m
ed by a variety of chemical means. But i
to conclude our lesson. I am afraid you
more to day than you will be able to reme

Caroline. I assure you that I have be
interested in it, ever to forget it; as for ni
seems to be but little to remember about
a very insignificant figure in comparison
although it composes a much larger port
mosphere.

Mrs. B. It will not appear so insignific
are better acquainted with it; for though
perform but a passive part in the atmosph
no very striking properties when considere
rate state, yet you will see by and by wh
portant agent it becomes, when combine
bodies. But no more of this at present;
serve it for its proper place.

Conversation VI.

On Hydrogen.

Caroline.

The next simple body we come to is
Pray what kind of a substance is that; is
le?

rs. B. Yes; we cannot obtain hydrogen in its concrete state. We are acquainted with it only gaseous form, as we are with oxygen and nitro-

roline. But in its gaseous state it cannot be called ple substance, since it is combined with caloric.

rs. B. True, my dear; but as we do not know ture of any substance which is not more or less ined with caloric, we are apt to say (rather incor- indeed) that a substance is in its pure state, when ined with caloric only.

drogen is derived from two Greek words, the ing of which is *to produce water.*

nily. And how does hydrogen produce water?

rs. B. Water is composed of 85 parts, by weight, ygen, chemically combined with 15 parts of hy- en gas, or (as it was formerly called) inflamable

roline. Really! Is it possible that water should combination of two gasses, and that one of them d be imflammable air? It must be a most extra- ary gas, that will produce both fire and water!

rs. B. Hydrogen, I assure you, though a consti- part of water, is one of the most combustible sub- es in nature.

nily. But I thought you said that combustion take place in no gas but oxygen?

rs. B. Do you recollect what the process of com- on consists in?

nily. In the combination of a body with oxygen, disengagement of light and heat.

rs. B. Therefore, when I say that hydrogen is ustible, I mean that it has an affinity for oxygen; ike all other combustible substances, it cannot unless supplied with oxygen, and heated to a er temperature.

roline. But I cannot conceive how, by mixing n parts of it, with eighty-five parts of oxygen gas, wo gasses can be converted into water.

(whether charcoal or metal) by means of which the water is decomposed, supplies, in cooling, a portion of the caloric which enters into the formation of the gas.

Emily. Water, then, may be resolved into a solid substance and a gas; the oxyen being condensed into a solid, by the loss of caloric, and the hydrogen expanded into a gas, by the acquisition of it.

Mrs. B. Very well; but remember that the basis of the oxygen gas, or what you call solid oxygen, can never be obtained alone; it can be separated from the hydrogen only by combining it with some other body for which it has a greater affinity.

Caroline. Hydrogen, I see, is like nitrogen, a poor dependant friend of oxygen, which is continually forsaken for greater favourites.

Mrs. B. The connection, or friendship, as you choose to call it, is much more intimate between oxygen and hydrogen, in the state of water, than between oxygen and nitrogen, in the atmosphere: for in the first case, there is a chemical union and condensation of the two substances; in the latter they are simply mixed together in their gaseous state. You will find, however, that, in some cases, nitrogen is quite as intimately connected with oxygen, as hydrogen is.—But this is foreign to our present subject.

Emily. Water, then, is an oxyd, though the atmospherical air is not?

Mrs. B. It is not commonly called an oxyd, though according to our definition, it may, no doubt, be referred to that class of bodies.

Caroline. I should like extremely to see water decomposed.

Mrs. B. I can easily gratify your curiosity by a much more easy process than the oxydation of charcoal or metal; the decomposition of water by these latter means, take up a great deal of time, and is attended with much trouble; for it is necessary that the charcoal or metal should be made red hot in a furnace, that the water should pass over them in a state of va-

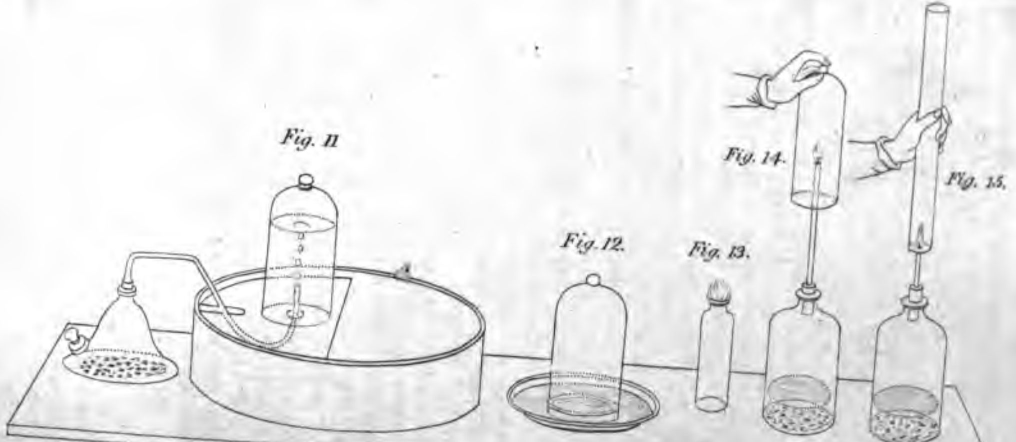


Fig. 11

Fig. 12.

Fig. 13.

Fig. 14.

Fig. 15.

hat the gas formed should be collected over the ath, &c. In short it is a very complicated affair, e same effect may be produced with the great- ity, by adding some sulphuric acid (a substance e nature of which you are not yet acquainted), to er which the metal is to decompose. The acid s the metal to combine with the oxygen of the o readily and abundantly, that no heat is requir- isten the process. Of this I am going to show instance.—I put into this bottle the water that is ecomposed, the metal that is to effect that de- ition by combining with the oxygen, and the ich is to fecilitate the combination of the metal oxygen. You will see with what violence these on each other.

line. But what metal is it that you employ for pose?

B. It is iron; and it is used in the state of as these present a greater surface to the acid solid piece of metal. For, as it is the surface metal which is acted upon by the acid, and is dis- o receive the oxygen produced by the decompo- f the water, it necessarily follows that the great- e surface, the more considerable is the effect. bbles which are now rising are hydrogen gas—

line. How disagreeably it smells!

B. It is indeed unpleasant, but not unwhole- We shall not, however, suffer any more to es- s it will be wanted for experiments. I shall re collect it in a glass receiver, by making it rough this bent tube, which will conduct it into er-bath. (*Plate* VI. *Fig.* 11.)

y. How very rapidly the gas escapes! it is

PLATE VI.

1. Apparatus for preparing and collecting hydrogen gas. Receiver full of hydrogen gas inverted over water. Slow combustion of hydrogen gas. Fig. 14. Appara- llustrating the formation of water by the combustion of n gas. Fig. 15. Apparatus for producing harmonic y the combustion of hydrogen gas.

perfectly transparent, and without any colour whatever. —Now the receiver is full—

Mrs. B. We shall therefore remove it and substitute another in its place. But you must observe, that when the receiver is full, it is necessary to keep it inverted with the mouth under water, otherwise the gas would escape. And in order that it may not be in the way, I introduce within the bath under the water, a saucer, into which I slide the receiver, so that it can be taken out of the bath and conveyed any where, the water in the saucer being equally effectual in preventing its escape as that in the bath. (*Plate* VI. *Fig.* 12.)

Emily. I am quite surprised to see what a large quantity of hydrogen gas can be produced by such a small quantity of water, especially as oxygen is the principal constituent of water.

Mrs. B. In weight it is: but not in volume. For though the proportion, by weight, is nearly six parts of oxygen to one of hydrogen, yet the proportion of the volume of the gasses, is about one part of oxygen, to two of hydrogen; so much heavier is the former than the latter.

Caroline. But why is the vessel in which the water is decomposed so hot? As the water changes from a liquid to a gaseous form, cold should be produced instead of heat.

Mrs. B. No; for if one of the constituents of water is converted into a gas, the other becomes solid in combining with the metal; and the caloric which the oxygen loses by being thus rendered solid, is just sufficient to transform the hydrogen into a gas.

Emily. In this case, neither heat nor cold would be produced; for the caloric disengaged from the oxygen, being immediately combined with the hydrogen, cannot become sensible?

Mrs. B. That is very true; but the sensible heat which is disengaged in this operation is not owing to the decomposition of the water, but to an extrication of latent heat produced by the mixture of water and sulphuric acid, as you saw in a former experiment.

If I now set the hydrogen gas, which is contained

in this receiver, at liberty all at once, and kindle it as soon as it comes in contact with the atmosphere, by presenting it to a candle, it will so suddenly and rapidly decompose the oxygen gas, by combining with its basis, that an explosion, or a *detonation* (as chemists commonly call it), will be produced. For this purpose, I need only take up the receiver, and quickly present its open mouth to the candle——so . . . . .

Caroline. It produced only a sort of hissing noise, with a vivid flash of light. I had expected a much greater report.

Mrs. B. And so it would have been, had the gasses been closely confined at the moment they were made to explode. If for instance, we were to put in this bottle a mixture of hydrogen gas and atmospheric air; and if, after corking the bottle, we should kindle the mixture by a very small orifice, from the sudden dilatation of the gasses at the moment of their combination, the bottle must either fly to pieces, or the cork be blown out with considerable violence.

Caroline. But in the experiment which we have just seen, if you did not kindle the hydrogen gas, would it not equally combine with the oxygen?

Mrs. B. Certainly not; have I not just explained to you the necessity of the oxygen and hydrogen gasses being burnt together, in order to combine chemically and produce water?

Caroline. That is true; but I thought this was a different combination, for I see no water produced.

Mrs. B. The water produced by this detonation was so small in quantity, and in such a state of minute division, as to be invisible. But water certainly was produced; for oxygen is incapable of combining with hydrogen in any other proportions than those that form water; therefore water must always be the result of their combination.

If, instead of bringing the hydrogen gas into sudden contact with the atmosphere (as we did just now) so as to make the whole of it explode the moment it is kindled, we allow but a very small surface of gas to burn in contact with the atmosphere, the combustion goes

on quietly and gradually at the point of contact, w
any detonation, because the surfaces brought to
are too small for the immediate union of gasses.
experiment is a very easy one. This phial with
row neck, (*Plate* VI. *Fig.* 13.), is full of hy
gas, and is carefully corked. If I take out th
without moving the phial, and quickly approa
candle to the orifice, you will see how different
sult will be—

Emily. How prettily it burns, with a blue
The flame is gradually sinking within the phial
it has entirely disappeared. But does not this c
tion likewise produce water?

Mrs. B. Undoubtedly. In order to make t
mation of water sensible to you, I shall procure
supply of hydrogen gas, by putting into this
(*Plate* VI. *Fig.* 14.) iron filings, water, and su
acid, materials similar to those which we have ju
for the same purpose. I shall then cork up the
leaving only a small orifice in the cork, with a p
glass tube fixed to it, through which the gas will
in a continued rapid stream.

Caroline. I hear already the hissing of t
through the tube, and I can feel a strong current
my hand.

Mrs. B. This current I am going to kind
the candle—see how vividly it burns—

Emily. It burns like a candle with a long fl
But why does this combustion last so much long
in the former experiment?

Mrs. B. The combustion goes on unintern
as long as the new gas continues to be produced.
if I invert this receiver over the flame, you wi
perceive its internal surface covered with a ve
dew, which is pure water—

Caroline. Yes, indeed; the glass is now qui
with moisture! How glad I am that we can *see* t
ter produced by this combustion.

Emily. It is exactly what I was anxious to se
I confess I was a little incredulous.

Mrs. B. If I had not held the glass-bell over the flame, the water would have escaped in the state of vapour, as it did in the former experiment. We have here, of course, obtained but a very small quantity of water; but the difficulty of procuring a proper apparatus, with sufficient quantities of gasses, prevents my shewing it to you on a larger scale.

The composition of water was discovered about the same period, both by Mr. Cavendish, in this country, and by the celebrated French chemist Lavoisier. The latter invented a very perfect and ingenious apparatus to perform with great accuracy, and upon a large scale, the formation of water by the combination of oxygen and hydrogen gasses. Two tubes, conveying due proportions, the one of oxygen, the other of hydrogen gas, are inserted at opposite sides of a large globe of glass, previously exhausted of air; the two streams of gas are kindled within the globe, by the electric spark, at the point where they come in contact; they burn together, that is to say, the hydrogen gas combines with the basis of the oxygen gas, the caloric of which is set at liberty; and a quantity of water is produced, exactly equal in weight to that of the two gasses introduced into the globe.

Caroline. And what was the greatest quantity of water ever formed in this apparatus?

Mrs. B. Several ounces; indeed, very near a pound, if I recollect right; but the operation lasted many days.

Emily. This experiment must have convinced all the world of the truth of the discovery. Pray, if improper proportions of the gasses were mixed and set fire to, what would be the result?

Mrs. B. Water would equally be formed, but there would be a residue of either one or other of the gasses, because, as I have already told you, hydrogen and oxygen will combine only in the proportions requisite for the formation of water.

There is another curious effect produced by the combustion of hydrogen gas, which I shall shew you, though I must acquaint you first, that I cannot well ex-

plain the cause of it, for this purpose, I must put some more materials into our apparatus, in order to obtain a stream of hydrogen gas, just as we have done before. The process is already going on, and the gas is rushing through the tube—I shall now kindle it with the taper.

Emily. It burns exactly as it did before——What is the curious effect which you were mentioning?

Mrs. B. Instead of the receiver, by means of which we have just seen the drops of water form, we shall invert over the flame this piece of tube, which is about two feet in length, and one inch in diameter (*Plate* VI. *Fig.* 15.) but you must observe that it is open at both ends.

Emily. What a strange noice it makes! something like the Æolian harp, but not so sweet.

Caroline. It is very singular, indeed; but I think rather too powerful to be pleasing. And is not this sound accounted for?

Mrs. B. That the percussion of glass, by a rapid stream of gas, should produce a sound, is not extraordinary; but the sound is here so peculiar, that no other gas has a similar effect. Perhaps it is owing to a brisk vibratory motion of the glass occasioned by the successive formation and condensation of small drops of water on the sides of the glass tube, and the air rushing in to replace the vacuum formed.*

Caroline. How very much this flame resembles the burning of a candle.

Mrs. B. The burning of a candle is produced by much the same means. A great deal of hydrogen is contained in candles, whether of tallow or wax. This hydrogen being converted into gas by the heat of the candle, combines with the oxygen of the atmosphere, and flame and water result from this combination. So that, in fact, the flame of a candle is nothing but the combustion of hydrogen gas. An elevation of temperature, such as is produced by a lighted match or taper, is required to give the first impulse to the combustion; but

* This ingenious explanation was first suggested by Dr. Delative. See Journals of the Royal Institution, vol. i. p. 259.

afterwards it goes on of itself, because the candle finds a supply of caloric in the successive quantities of *chemical* heat which becomes *sensible* by the combination of the two gasses. But there are other accessary circumstances connected with the combustion of candles and lamps, which I cannot explain to you till you are acquainted with *carbone*, which is one of their constituent parts. In general, however, whenever you see flame, you may infer that it is owing to the formation and burning of hydrogen gas; for flame is the peculiar mode of burning of hydrogen gas, which, with only one or two apparent exceptions, does not belong to any other combustible.

Emily. You astonish me! I understood that flame was the caloric abandoned by the basis of the oxygen gas, in all combustions whatever?

Mrs. B. Your error proceeded from your vague and incorrect idea of flame; you have confounded it with light and caloric in general. Flame always implies caloric, since it is produced by the combustion of hydrogen gas; but all caloric does not imply flame. Many bodies burn with intense heat without producing flame. Coals, for instance, burn with flame until all the hydrogen which they contain is evaporated; but when they afterwards become red hot, much more caloric is disengaged than when they produce flame.

Caroline. But the iron wire, which you burnt in oxygen gas, appeared to me to emit flame; yet as it was a simple metal, it could contain no hydrogen?

Mrs. B. It produced a sparkling dazzling blaze of light, but no real flame.

Emily. And what is the cause of the regular shape of the flame of a candle?

Mrs. B. The regular stream of hydrogen gas which exhales from its combustible matter.

Caroline. But the hydrogen gas must from its great levity, ascend into the upper regions of the atmosphere; why therefore does not the flame continue to accompany it?

Mrs. B. The combustion of the hydrogen gas is completed at the point where the flame terminates; it

then ceases to be hydrogen gas, as
its combustion into watery vapour; bı
minute division as to be invisible.

Caroline. I do not understand whı
wick of a candle; since the hydrogen
without it?

Mrs. B. The combustible matter
be decomposed in order to emit the h
the wick is instrumental in effectiı
tion. Its combustion first melts the c
and . . . . . .

Caroline. But in lamps the coml
already fluid, and yet they also requi

Mrs. B. I was going to add thı
burning wick (by the power of capillaı
ually draws up the fluid to the point
takes place; for you must have obser
does not burn quite to the bottom.

Caroline. Yes; but I do not unde
not.

Mrs. B. Because the air has not
to that part of the wick which is imm
with the candle, as to the part just
heat there is not sufficient to produce i
the combustion therefore begins a litt
But we dwell too long on a subject
yet thoroughly understand.—I have a
to shew you with hydrogen gas, whi
tertain you. Have you ever blown
and water?

Emily. Yes, often, when I was a
to make them float in the air by blowiı

Mrs. B. We shall fill some suc
drogen gas, instead of atmospheric
see with what ease and rapidity they
out the assistance of blowing, from t
gas.—Will you mix some soap and
this bladder with the gas contained in
stands on the shelf in the water-bath.

Caroline. What is the use of the
turn-cock at the top of the receiver?

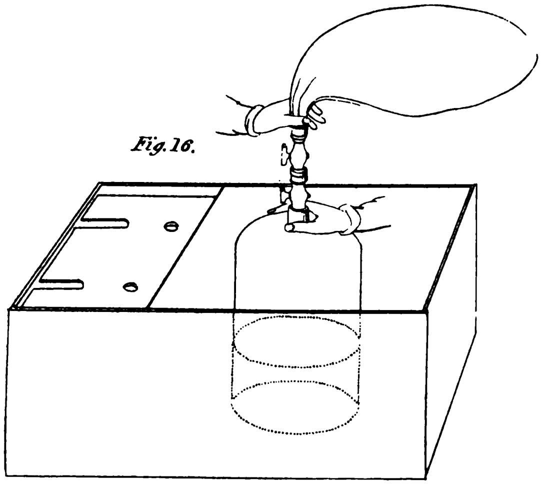


Fig. 16.

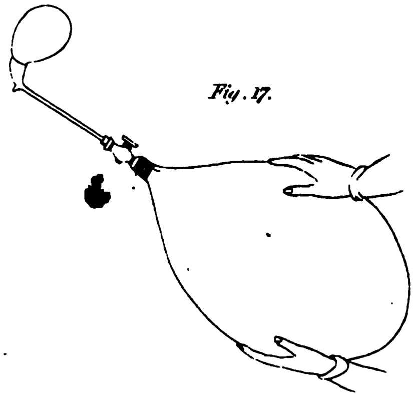


Fig. 17.

rs. B. It is to afford a passage to the gas when re-d. There is, you see, a similar stop-cock fasten- this bladder, which is made to fit that on the re-r. I screw them one on the other, and now turn wo cocks, to open a communication between the ver and the bladder; then, by sliding the receiver le shelf, and gently sinking it into the bath, the r rises in the receiver and forces the gas into the ler. (*Plate* VII. *Fig.* 16.)

roline. Yes, I see the bladder swell as the water in the receiver.

rs. B. I think that we have already a sufficient tity in the bladder for our purpose ; we must be ul to stop both the cocks before we separate the ler from the receiver, lest the gas should escape.— I must fix a pipe to the stopper of the bladder, by dipping its mouth into the soap and water, take few drops ; then I again turn the cock, and squeeze ladder in order to force the gas into the soap and r at the mouth of the pipe. (*Plate* VII. *Fig.* 17.)

mily. There is a bubble—but it burns before it s the mouth of the pipe.

rs. B. We must have patience and try again; not so easy to blow bubbles by means of a bladder, mply with the breath.

roline. Perhaps there is not soap enough in the r ; I should have had warm water, it would have lved the soap better.

mily. Does not some of the gas escape between bladder and the pipe ?

Irs. B. No, they are perfectly air-tight ; we shall eed presently, I dare say.

roline. Now a bubble ascends ; it moves with the dity of a balloon. How beautifully it refracts the t!

mily. It has burst against the ceiling—you suc-

PLATE VII.

g. 16. Apparatus for transferring gasses from a receiver a bladder. Fig. 17. Apparatus for blowing soap bubbles.

ceed now wonderfully ; but why do they all asc
burst against the ceiling ?

Mrs. B. Hydrogen gas is so much lighter
mospherical air, that it ascends rapidly with
light envelope, which is burst by the force wit
it strikes the ceiling.

Air balloons are filled with this gas, and if tl
ried no other weight than their covering, would
as rapidly as these bubbles.

Caroline. Yet their covering must be much
than that of these bubbles ?

Mrs. B. Not in proportion to the quantity
they contain. I do not know whether you ha
been present at the filling of a large balloon.
paratus for that purpose is very simple. It co
a number of vessels, either jars or barrels, i
the materials for the formation of the gas are
each of these being furnished with a tube, an
municating with a long flexible pipe, which
the gas into the balloon.

Emily. But the fire balloons which were firs
ed, and have been since abandoned, on account
being so dangerous, were constructed, I sup
a different principle.

Mrs. B. They were filled simply with atn
cal air, considerably rarefied, and the necessit
ing a fire underneath the balloon, in order to
the rarefaction of the air within it, was the circ
productive of so much danger.

If you are not yet tired of experiments, I l
ther to shew you. It consists in filling soap
with a mixture of hydrogen and oxygen gasse
proportions that form water ; and afterward
fire to them.

Emily. They will detonate, I suppose ?

Mrs. B. Yes, they will. As you have
method of tranferring the gas from the rece
the bladder it is not necessary to repeat it.
therefore provided a bladder which contains a
portion of oxygen and hydrogen gasses, and
only to blow bubbles with it.

Caroline. Here is a fine large bubble rising—shall I set fire to it with the candle?

Mrs. B. If you please.

Caroline. Heavens, what an explosion!—It was like the report of a gun: I confess it frightened me much, I never should have imagined it could be so loud.

Emily. And the flash was as vivid as lightning.

Mrs. B. The combination of the two gasses takes place during that instant of time that you see the flash, and hear the detonation.

Emily. This has a strong resemblance to thunder and lightning.

Mrs. B. These phenomena, however, are most probably of an electrical nature. Yet various meteorological effects may be attributed to accidental detonations of hydrogen gas in the atmosphere; for nature abounds with hydrogen; it constitutes a very considerable portion of the whole mass of water belonging to our globe, and from that source, almost every other body obtains it. It enters into the composition of all animal substances, and of a great number of minerals; but it is most abundant in vegetables. From this immense variety of bodies, it is often spontaneously disengaged; its great levity makes it rise into the superior regions of the atmosphere, and when, either by an electric spark, or any casual elevation of temperature, it takes fire, it may produce such meteors or luminous appearances as are occasionally seen in the atmosphere. Of this kind are probably those broad flashes which we often see on a summer evening, without hearing any detonation.

Emily. Every flash I suppose, must produce a quantity of water?

Caroline. And this water, naturally, descends in the form of rain?

Mrs. B. That probably is often the case, though it is not a necessary consequence; for the water may be dissolved by the atmosphere, as it descends towards the lower regions, and remain there in the form of clouds. But pray do not question me too closely on this subject,

for the phenomena of the atmosphere are understood; and even with the little that is but imperfectly acquainted.

Conversation VII.

On Sulphur and Phosphorus.

Mrs. B.

Sulphur is the next simple substanc under our consideration. It differs in one e from the preceding, as it exists in a solid temperature of the atmosphere.

Caroline. I am glad that we have at las to examine; one that we can see and touc it not with sulphur that the points of match ed to make them easily kindle?

Mrs. B. Yes, it is; and you therefore that sulphur is a very combustible substan dom discovered in nature in a pure unmi great is its affinity for other substances, th constantly found combined with some of most commonly united with metals, under and is separated from them by a very sin It exists likewise in many mineral waters, a etables yield it in various proportions, es of the cruciform tribe. It is also found in ter; in short, it may be discovered in g quantity, in the mineral, vegetable, and doms.

Emily. I have heard of *flowers of sulp* the produce of any plant?

Mrs. B. By no means: they consist of

Fig. 18.

Sublimation of Sulphur

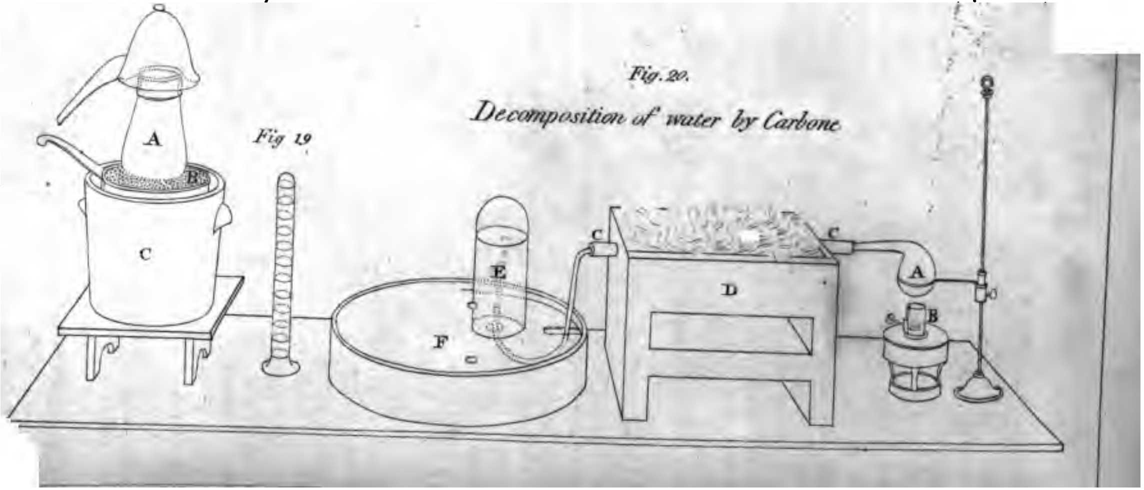


Fig 19

Fig. 20.

Decomposition of water by Carbone

a common sulphur reduced to a very fine powder by
rocess called *sublimation*.—You see some of it in this
al; it is exactly the same substance as this lump of
phur, only its colour is a paler yellow, owing to its
e of very minute division.

Emily. Pray what is sublimation?

Mrs. B. It is the evaporation, or, more properly
aking, the volatilization of solid substances, which, in
ling, condense again in a concrete form. The pro-
s, in this instance, must be performed in a closed
sel, both to prevent combustion, which would take
ce if the access of air was not carefully precluded,
l likewise in order to collect the substance after the
ration. As it is rather a slow process, we shall not try
experiment now; but you will understand it perfect-
f I show you the apparatus used for the purpose
ate VIII. *Fig*. 18.) Some lumps of sulphur are
into a receiver of this kind which is called a *cucurbit*.
shape, you see, somewhat resembles that of a pear,
l it is open at the top so as to adapt itself exactly
a kind of conical receiver of this sort called the head.
e cucurbit, thus covered with its head, is placed
r a sand-bath; this is nothing more than a vessel
l of sand, which is kept heated by a furnace, such
you see here, so as to preserve the apparatus in a
derate and uniform temperature. The sulphur
n soon begins to melt, and immediately after this a
ck white smoke rises, which is gradually deposited
hin the head, or upper part of the apparatus, where
condenses against the sides, somewhat in the form
a vegetation, whence it has obtained the name of
wers of sulphur. This apparatus, which is called
alembic, is highly useful in all kinds of distillations,
you will see when we come to treat of those opera-
ns. Alembics are not commonly made of glass,
e this, which is applicable only to distillations upon

PLATE VIII.

Fig. 18. A. Alembic. B. Sand-bath. C. Furnace. Fig. 19.
udiometer. Fig. 20. A. Retort containing water. B. Lamp to
at the water. C. C. Porcelain tube containing Carbone. D.
urnace through which the tube passes. E. Receiver for the gas
roduced. F. Water-bath.

Mrs. B. It is of no use in sublimations; b
tillations (the general object of which is to e
by heat, in closed vessels, the volatile parts
pound body, and to condense them again into
it serves to carry off the condensed fluid, whi
wise would fall back into the cucurbit. But th
er foreign to our present subject. Let us ret
sulphur. You now perfectly understand, I
what is meant by sublimation?

Emily. I believe I do. Sublimation appea
sist in destroying, by means of heat, the att
aggregation of the particles of a solid body,
thus volatilized; and as soon as they lose t
which produced that effect, they are deposi
form of a fine powder.

Caroline. It seems to me to be somewhat
the transformation of water into vapour, whi
to its liquid state when deprived of caloric.

Emily. There is this difference, however
sulphur does not return to its former state, sin
of lumps, it changes to a fine powder.

Mrs. B. Chemically speaking, it is exactl
substance, whether in the form of lump or pow
if this powder be melted again by heat, it wi
ing, be restored to the same solid state in wh

line. Sublimation appears to me like the begin-
f combustion, for the completion of which one
stance only is wanting, the absorption of oxygen.

. B. But that circumstance is every thing. No
al alteration is produced in sulphur by sublima-
vhilst in combustion it combines with the oxygen
rms a new compound totally different in every
from sulphur in its pure state.—We shall now
me sulphur, and you will see how very differ-
result will be. For this purpose I put a small
y of flowers of sulphur into this cup, and place
dish, into which I have poured a little water; I
t fire to the sulphur with the point of this hot
for its combustion will not begin unless its tem-
e be considerably raised.—You see that it burns
faint blueish flame; and as I invert over it this
r, white fumes arise from the sulphur and fill the
—You will soon perceive that the water is rising
the receiver, a little above its level in the plate.
l, Emily, can you account for this?

y. I suppose that the sulphur has absorbed the
from the atmospherical air within the receiver;
at we shall find some oxygenated sulphur in the
As for the white smoke, I am quite at a loss to
vhat it may be.

B. Your first conjecture is very right; but you
te mistaken in the last; for nothing will be left
cup. The white vapour is the oxygenated sul-
which assumes the form of an elastic fluid of a
t and offensive smell, and is a powerful acid.
ou see a chemical combination of oxygen and
, producing a true gas, which would continue
nder the pressure and at the temperature of the
here, if it did not unite with the water in the
o which it imparts its acid taste and all its acid
ies.—You see, now, with what curious effects
nbustion of sulphur is attended.

line. This is something quite new; and I con-
at I do not perfectly understand why the sulphur
cid.

B. It is because it unites with oxygen, which
eneral acidifying principle. And, indeed, the

word *oxygen*, is derived from two Greek words signifying *to produce an acid.*

Caroline. Why then is not water, which contains such a quantity of oxygen, acid?

Mrs. B. Because hydrogen, which is the other constituent of water, is not susceptible of acidification. I believe it will be necessary, before we proceed further, to say a few words of the general nature of acids, though it is rather a deviation from our plan of examining the simple bodies separately, before we consider them in a state of combination.

Acids may be considered as a peculiar class of *burnt* bodies, which, during their combustion, or combination with oxygen, have acquired very characteristic properties. They are chiefly discernable by their sour taste, and by turning red most of the blue vegetable colours. These two properties are common to the whole class of acids; but each of them is distinguished by other peculiar qualities. Every acid consists of some particular substance (which constitutes its basis, and is different in each), and of oxygen, which is common to them all.

Emily. But I do not clearly see the difference between acids and oxyds?

Mrs. B. Acids were, in fact, oxyds, which, by the addition of a sufficient quantity of oxygen, have been converted into acids. For acidification, you must observe, always implies previous oxydation, as a body must have combined with the quantity of oxygen requisite to constitute it an oxyd, before it can combine with the greater quantity that is necessary to render it an acid.

Caroline. Are all oxyds capable of being converted into acids?

Mrs. B. Very far from it; it is only certain substances which will enter into that peculiar kind of union with oxygen that produces acids, and the number of these is proportionally very small; but all burnt bodies may be considered as belonging either to the class of oxyds, or to that of acids. At a future period, we shall enter more at large upon this subject. At present, I

have but one circumstance further to point out to your observation respecting acids: it is, that most of them are susceptible of two degrees of acidification, according to the different quantities of oxygen with which their basis combines.

Emily. And how are these two degrees of acidification distinguished?

Mrs. B. By the peculiar properties that result from them. The acid we have just made is the first or weakest degree of acidification, and is called *sulphurous acid;* if it were fully saturated with oxygen, it would be called *sulphuric acid.* You must therefore remember, that in this, as in all acids, the first degree of acidification is expressed by the termination in *ous;* the stronger, by the termination in *ic*.

Caroline. And how is the sulphuric acid made?

Mrs. B. By burning sulphur in pure oxygen gas, and thus rendering its combustion much more complete. I have provided some oxygen gas for this purpose; it is in that bottle, but we must first decant the gas into the glass receiver which stands on the shelf in the bath, and is full of water.

Caroline. Pray, let me try to do it, Mrs. B?

Mrs. B. It requires some little dexterity—hold the bottle completely under water, and do not turn the mouth upwards, till it is immediately under the aperture in the shelf, through which the gas is to pass into the receiver, and then turn it up gradually.—Very well, you have only let a few bubbles escape, and that must be expected at a first trial.—Now I shall put this piece of sulphur into the receiver, through the opening at the top, and introduce along with it a small piece of lighted tinder to set fire to it. This requires being done very quickly, lest the atmospherical air should get in, and mix with the pure oxygen gas.

Emily. How beautifully it burns!

Caroline. But it is already buried in the thick vapour. This I suppose is sulphuric acid?

Emily. Are these acids always in a gaseous state?

Mrs. B. Sulphurous acid, as we have already observed, is a permanent gas, and can be obtained in a

liquid form only by condensing it in wa
state, the sulphurous acid is invisible,
the form of white smoke, only from it
the moisture. But the vapour of sulp
you have just seen to rise during the c
a gas, but only a vapour, which conde
sulphuric acid, merely by losing its ca
condensation is much hastened and pro
ing the vapour into cold water ; which
be separated from the acid by evaporat

Before we quit the subject of sulphur
that it is susceptible of combining wit
of substances, and especially with
which you are already acquainted. H
dissolve a small portion of it.

Emily. What ; can a gas dissolve a

Mrs. B. Yes ; a solid substance m
ly divided by heat, as to become solubl
there are several instances of it. Bu
serve that, in this case, a chemical sol
say, a combination of the sulphur wit
gas, is produced. In order to effect t
must be strongly heated in contact wit
heat reduces the sulphur to such a st
division, and diffuses it so thoroughly t
that they combine and incorporate to
a proof that there must be a chemica
the sulphur and the gas, it is sufficient
they are not separated when the sulph
loric by which it was volatilized. Be
dent, from the peculiar feted smell of
is a new compound totally different fr
constituents ; it is called *sulphurated hy*
is contained in great abundance in sulp
waters.

Caroline. Are not the Harrogate w
ture ?

Mrs. B. Yes ; they are naturally in
sulphurated hydrogen gas, and there
springs of the same kind ; which she
must often be formed in the bowels
spontaneous processes of nature.

Caroline. And could not such waters be made artificially by impregnating common water with this gas?

Mrs. B. Yes; they can be so well imitated as perfectly to resemble the Harrogate waters.

Sulphur combines likewise with phosphorus, and with the alkalies, and alkaline earths, substances with which you are yet unacquainted. We cannot, therefore, enter into these combinations at present. In our next lesson we shall treat of phosphorus.

Emily. May we not begin that subject to-day; this lesson has been so short?

Mrs. B. I have no objection, if you are not tired. What do you say, Caroline?

Caroline. I am as desirous as Emily of prolonging the lesson to-day, especially as we are to enter on a new subject; for I confess that sulphur has not appeared to me so interesting as the other simple bodies.

Mrs. B. Perhaps you may find phosphorus more entertaining. You must not, however, be discouraged when you meet with some parts of a study less amusing than others; it would answer no good purpose to select the most pleasing parts, since, if we did not proceed with some method, in order to acquire a general idea of the whole, we could scarcely expect to take interest in any particular subjects.

PHOSPHORUS.

PHOSPHORUS is a simple substance that was formerly unknown. It was first discovered by Brandt, a chemist of Hamburgh, whilst employed in researches after the philospher's stone; but the method of obtaining it remained a secret till it was a second time discovered both by Kunckel and Boyle, in the year 1680. You see a specimen of phosphorus in this phial; it is generally moulded into small sticks of a yellowish colour, as you find it here.

Caroline. I do not understand in what the discovery consisted; there may be a secret method of making a composition, but a simple body cannot be *made*, it can only be *found*.

Mrs. B. But a body may exist in nature so closely combined with other substances, as to elude the observation of chemists, or render it extremely difficult to obtain it in its simple state. This is the case with phosphorus, which is always so intimately combined with other substances, that its existence remained unnoticed till Brandt discovered the means of obtaining it free from all combinations. It is found in all animal substances, and is now chiefly extracted from bones, by a chemical process. It exists also in some plants, that bear s strong analogy to animal matter in their chemical composition.

Emily. But is it never found in its simple state?

Mrs. B. Never, and this is the reason of its having remained so long undiscovered.

Emily. It is possible, then, that in course of time other new simple bodies may be discovered?

Mrs. B. Undoubtedly; and we may also learn that some of those, which we now class among the simple bodies, may, in fact, be compound; indeed, you will soon find that discoveries of this kind are by no means unfrequent.

Phosphorus is eminently combustible; it melts and takes fire at the temperature of 100°, and absorbs in its combustion nearly once and a half its own weight of oxygen.

Caroline. What! will a pound of phosphorus consume a pound and a half of oxygen?

Mrs. B. So it appears from accurate experiments. I can show you with what violence it combines with oxygen, by burning some of it in that gas. We must manage the experiment in the same manner as we did the combustion of sulphur.—You see I am obliged to cut this little bit of phosphorus under water, otherwise there would be danger of its taking fire by the heat of my fingers.—I now put it into the receiver, and kindle it by means of a hot wire.

Emily. What a blaze ! I can hardly look at it. I never saw any thing so brilliant. Does it not hurt your eyes, Caroline ?

Caroline. Yes ; but still I cannot help looking at it. A prodigious quantity of oxygen must indeed be absorbed, when so much light and caloric are disengaged !

Mrs. B. In the combustion of a pound of phosphorus, a sufficient quantity of caloric is set free to melt upwards of a hundred pounds of ice ; this has been computed by direct experiments with the calorimeter.

Emily. And is the result of this combustion, like that of sulphur, an acid ?

Mrs. B. Yes ; phosphoric acid. And had we duly proportioned the phosphorus and the oxygen, they would have been completely converted into phosphoric acid, weighing together, in this new state, exactly the sum of their weights separately. The water would have ascended into the receiver, on account of the vacuum formed, and would have filled it entirely. In this case, as in the combustion of sulphur, the acid vapour formed is absorbed and condensed in the water of the receiver. But when this combustion is performed without any water or moisture being present, the acid then appears in the form of concrete whitish flakes, which are, however, extremely ready to melt upon the least admission of moisture.

Emily. Does phosphorus, in burning in atmospherical air, produce, like sulphur, a weaker sort of the same acid ?

Mrs. B. No ; for it burns in atmospherical air nearly at the same temperature, as in pure oxygen gas ; and it is, in both cases, so strongly disposed to combine with the oxygen, that the combustion is perfect, and the product similar ; only in atmospherical air being less rapidly supplied with oxygen, the process is performed in a slower manner.

Caroline. But is there no method of acidifying phosphorus in a slighter manner ; so as to form *phosphorus* acid ?

Mrs. B. Yes, there is. When simply exposed to

sible ; a whitish vapour arises from this cor which uniting with water, condenses into liqu phorus acid.

Caroline. Is it not very singular that ph should burn at so low a temperature in atmo air, whilst it does not burn in pure oxygen wi application of heat?

Mrs. B. So it at first appears. But this stance seems to be owing to the nitrogen ga atmosphere. This gas dissolves small particle phorus, which being thus minutely divided a ed in the atmospherical air, combines with the and undergoes this slow combustion. But the fect does not take place in oxygen gas, becaus capable of dissolving phosphorus ; it is ther cessary, in this case, that heat should be appli fect that division of particles, which, in the f stance, is produced by the nitrogen.

Emily. I have seen letters written with ph which are invisible by day-light, but may b the dark by their own light. They look as if t written with fire ; yet they do not seem to bur

Mrs. B. But they do really burn ; for it is slow combustion that the light is emitted ; a

Emily. And the more oxygen is contained in the nosphere, the purer I suppose it is esteemed ?

Mrs. B. Certainly. Phosphorus, when melted, mbines with a great variety of substances. With lphur it forms a compound so extremely combusti-e, that it immediately takes fire on coming in contact ith the air. It is with this composition that the phos-oric matches are prepared, which kindle as soon as ey are taken out of their case and are exposed to the r.

Emily. I have a box of these curious matches ; but have observed, that in very cold weather, they will ot take fire without being previously rubbed.

Mrs. B. By rubbing them you raise their tempera-ure ; for you know, friction is one of the means of ex-icating heat.

Emily. Will phosphorus combine with hydrogen as, as sulphur does ?

Mrs. B. Yes ; and the compound gas which re-ults from this combination has a smell still more fetid an the sulphurated hydrogen ? it resembles that of arlic.

The *phosphorated hydrogen gas* has this remarkable eculiarity, that it takes fire spontaneously in the at-osphere at any temperature. It is thus that are pro-uced those transient flames, or flashes of light, called y the vulgar *Will-of-the-Wisp*, or more properly *Ignes-fatui*, which are often seen in church yards, and places here the putrefaction of animal matter exhales phos-horus and hydrogen gas.

Caroline. Country people, who are so much fright-ned by those appearances, would soon be reconciled o them, if they knew from what a simple cause they roceed.

Mrs. B. There are other combinations of phospho-us that have also very singular properties, particularly hat which results from its union with lime.

Emily. Is there any name to distinguish the com-bination of two simple substances, like phosphorus and lime, neither of which are oxygen, and which there-fore can produce neither an oxyd nor an acid ?

Mrs. B. The names of such combinations a posed from those of their ingredients, mere slight change in their termination. Thus we combination of sulphur with lime a *sulphuret,* of phosphorus, a *phosphoret of lime.* This latt pound, I was going to say, has the singular of decomposing water, merely by being thro it. It effects this by absorbing the oxygen o in consequence of which bubbles of hydrogen cend, holding in solution a small quantity of p rus.

Emily. These bubbles then are *phosphorate gen gas?*

Mrs. B. Yes; and they produce the sing pearance of a flash of fire issuing from water, bubbles kindle and detonate on the surface of ter, at the instant that they come in contact w atmosphere.

Caroline. Is not this effect nearly similar to t duced by the combination of phosphorus and o or, more properly speaking, the *phosphoret of s*

Mrs. B. Yes; but the phenomenon appea extraordinary in this case, from the presence o and from the gaseous form of the cambustibl pound. Besides the experiment surprises by it simplicity. You only throw a piece of phosph lime into a glass of water, and bubbles of fire w mediately issue from it.

Caroline. Cannot we try the experiment?

Mrs. B. Very easily; but we must do it in th air; for the smell of the phosphorated hydrog is so extremely fetid, that it would be intolerable house. But before we leave the room, we ma duce by another process some bubbles of the

which take fire and detonate as they issue from the water.

Caroline. There is one—and another. How curious it is !—But I do not understand how this is produced ?

Mrs. B. It is the consequence of a display of affinities too complicated, I fear, to be made perfectly intelligible to you at present.

In a few words, the reciprocal action of the potash, phosphorus, caloric, and water, are such that some of the water is decomposed, and the hydrogen thereby formed carries off some minute particles of phosphorus, with which it forms phosphorated hydroden gas, a compound which spontaneously takes fire at almost any temperature.

Emily. What is that circular ring of smoke which slowly rises from each bubble after its detonation ?

Mrs. B. It consists of water and phosphoric acid in vapour, which are produced by the combustion of the hydrogen and phosphorous.

Conversation VIII.

On Carbone.

Caroline,

To-day, Mrs. B.—I believe we are to learn the nature and properties of carbone. This substance is quite new to me ; I never heard it mentioned before.

Mrs. B. Not so new as you imagine ; for carbone is nothing more than charcoal in a state of perfect purity.

from it the simple substance in question. I
od by which charcoal is usually obtained, i
commonly called *making* it ; but, upon ex
you will find this process to consist simply i
ing it from other substances with which i
combined in nature.

Carbone forms a considerable part of the
ter of all organized bodies ; but it is most
in the vegatable creation, and it is chiefl
from wood. When the oil and water (whicl
constituents of vegetable matter) are evap
black, porous, brittle substance that remai
coal.

Caroline. But if heat be applied to the
der to evaporate the oil and water, will not
rature of the charcoal be raised so as to ma
and if it combines with oxygen, can we
call it pure ?

Mrs. B. I was going to say, that in thi
the air must be excluded.

Caroline. How then can the vapour of
water fly off?

Mrs. B. In order to produce charcoal in
state (which is, even then, but a less impe
carbone) the operation should be performed

charcoal, such as is used in kitchens and manufactures, is performed on a much larger scale, and by an easier and less expensive process.

Emily. I have seen the process of making common charcoal. The wood is ranged on the ground in a pile of a pyramidical form, with a fire underneath; the whole is then covered with clay, a few holes only being left for the circulation of air.

Mrs. B. These holes are closed as soon as the wood is fairly lighted, so that the combustion is checked, or at least continues but in a very imperfect manner; but the heat produced by it is sufficient to force out and volatilize, through the earthy cover, most part of the oily and watery principles of the wood, although it cannot reduce it to ashes.

Emily. Is pure carbone as black as charcoal?

Mrs. B. The more charcoal is purified, that is to say, the nearer it approaches to the state of simple carbone, the deeper its black colour appears; but the utmost efforts of chemical art, are not able to bring it to its perfect elementary state; for in that state it is both colourless and transparent, and as different in appearance from charcoal as any substance can possibly be. This ring which I wear on my finger, owes its brilliancy to a small piece of carbone.

Caroline. Surely you are jesting, Mrs. B.?

Emily. I thought that your ring was diamond?

Mrs. B. It is so. But diamond is nothing more than carbone in its purest and most perfect state.

Emily. That is astonishing! Is is possible to see two things apparently more different than diamond and charcoal?

Caroline. It is, indeed, curious to think that we adorn ourselves with jewels of charcoal?

Mrs. B. When you are better acquainted with the nature of chrystalization, in which state bodies are generally the purest, you will more readily conceive the possibility of carbone assuming the transparency and brilliancy of diamond.

There are many other substances, consisting chiefly

of carbone, that are remarkably white. Cotton, for instance, is almost wholly carbone.

Caroline. That, I own, I could never have imagined !—But pray, Mrs. B. Since it is know of what substance diamond and cotton are composed, why should they not be manufactured, or imitated, by some chemical process, which would render them much cheaper and more plentiful than the present mode of obtaining them ?

Mrs. B. You might as well my dear propose that we should make flowers and fruit, nay perhaps even animals, by a chemical process ; for it is known of what these bodies consist, since every thing which we are acquainted with in nature, is formed from the various simple substances that we have enumerated. But, you must not suppose that a knowledge of the component parts of a body will in every case enable us to imitate it. It is much less difficult to decompose bodies, and discover of what materials they are made, than it is to recompose them. The first of these processes is called *analysis*, the last *synthesis*. When we are able to ascertain the nature of a substance by both these methods, so that the result of one confirms that of the other, we obtain the most complete knowledge of it that we are capable of acquiring. This is the case with water, with the atmosphere, with most of the oxyds, acids, and neutral salts, and with many other compounds. But the more complicated combinations of nature, even in the mineral kingdom, are in general beyond our reach, and any attempt to imitate organized bodies must ever prove fruitless ; their formation is a secret that rests in the bosom of the Creator. You see, therefore, how vain it would be to attempt the formation of cotton by chemical means. But, surely, we have no reason to regret our inability in this instance, when nature has so clearly pointed a method of obtaining it in perfection and abundance.

Caroline. I did not imagine that the principle of life could be imitated by the aid of chemistry ; but it did not appear to me ridiculous to suppose that chemists migh attain a perfect imitaion of inanimate nature.

Mrs. B. They have succeeded in this point in a

variety of instances; but, as you justly observe, the principle of life, or even the minute and intimate organization of the vegetable kingdom, are secrets that have almost entirely eluded the researches of philosophers; nor do I imagine that human art will ever be capable of investigating them with complete success.

Emily. But diamond, since it consists merely of one simple unorganized substance, might be, one would think, perfectly imitable by art?

Mrs. B. It is sometimes as much beyond our power to obtain a simple body in a state of perfect purity, as it is to imitate a complicated combination; for the operations by which nature decomposes bodies are frequently as inimitable as those which she uses for their combination. This is the case with carbone; all the efforts of chemists to separate it entirely from other substances, have been fruitless, and in the purest state in which it can be obtained by art, it still retains a portion of oxygen, and probably of some other foreign ingredients. It is in the diamond alone, as I have observed before, that carbone is supposed to exist in its perfect form; we are ignorant of the means which nature employs to bring it to that state; it may probably be the work of ages, to purify, arrange, and unite the particles of carbone in the form of diamond. And with regard to our artificial carbone, which we call charcoal, we must consider it as an oxyd of carbone; since, whatever may be the means employed for obtaining it, it always retains a small portion of oxygen. Here is some charcoal in the purest state we can procure it: you see that it is a very black, brittle, light, porous substance, entirely destitute of either taste or smell. Heat, without air, produces no alteration in it, as it is not volatile; but on the contrary, it invariably remains at the bottom of the vessel after all the others parts of the vegetable are evaporated.

Emily. Carbone is, no doubt, combustible, since you say that charcoal would absorb oxygen if air was admitted during its preparation?

Caroline. Unquestionably. Besides, you know, Emily, how much it is used in cooking. But pray what is

some hydrogen.

Mrs. B. Very true; but you must re
charcoal, especially that which is used fo
purposes, is very far from being pure. It g
tains, as we have seen, not only a small
oxygen, but also some remains of the va
component parts of vegetables, and hydrog
larly, which accounts for the flame in questi

Caroline. But what becomes of the ca
during its combustion?

Mrs. B. It gradually combines with the
the atmosphere, in the same way as sulphu
phorus, and, like those substances, it is co
a peculiar acid, which flies off in a gas
There is this difference, however, that the
in this instance, as in the two cases just m
mere condensable vapour, but a permanent
which always remains in the state of gas,
pressure and at any temperature. The na
acid was first ascertained by Dr. Black, of
and, before the introduction of the new no
it was called *fixed air*. It is now distingui
more appropriate name of *carbonic acid gas.*

Emily. Carbone, then, can be volatilize
ing, though, by heat alone, no such effect is

Mrs. B. Yes; but then it is no longer

Emily. That is true ; we may conceive the basis of the oxygen, and of the other gasses, to be solid, heavy substances, like carbone ; but so much expanded by caloric, as to become invisible.

Caroline. But does not the carbonic acid gas partake of the blackness of charcoal ?

Mrs. B. Not in the least. Blackness, you know, does not appear to be essential to carbone, and it is pure carbone, and not charcoal, that we must consider as the basis of carbonic acid. We shall make some carbonic acid, and, in order to hasten the process, we shall burn the carbone in oxygen gas.

Emily. But how can you make carbonic acid, unless you can burn diamond ; since that alone is pure carbone ?

Mrs. B. Charcoal will answer the purpose still better ; for the carbone being, in that state, already combined with some portion of oxygen, it will require less of that principle to complete its oxygenation.

Caroline. But is it possible to burn diamond ?

Mrs. B. Yes, it is ; and, in order to effect this combustion, nothing more is required than to apply a sufficient degree of heat by means of the blow-pipe, and of a stream of oxygen gas. Indeed it is by burning diamond that its chemical nature has been ascertained. It is long since it has been known, as a combustible substance, but it is within these few years only that the product of its combustion has been proved to be pure carbonic acid. This discovery is due to Mr. Tennant. But still more recent experiments have shown, that diamond requires a greater proportion of oxygen than charcoal to be converted into carbonic acid. It appears that 15 parts of diamond require 85 parts of oxygen to form 100 parts of carbonic acid ; whilst 28 parts of charcoal take up only 72 parts of oxygen to produce 100 parts of carbonic acid ; from which it is naturally inferred that carbone, in the state of charcoal, is already combined with a portion of oxygen.

Now let us try to make some carbonic acid.—Will you, Emily, decant some oxygen gas from this large jar into the receiver in which we are to burn the car-

bone; and I shall introduce this small piece of c coal, with a little lighted tinder, which will be nece ry to give the first impulse to the combustion.

Emily. I cannot conceive how so small a piece tinder, and that but just lighted, can raise the temp ature of the carbone sufficiently to set fire to it; fo can produce scarcely any sensible heat, and it hard touches the carbone.

Mrs. B. The tinder thus kindled has only heat nough to begin its own combustion, which, howeve soon becomes so rapid in the oxygen gas, as to rais the temperature of the charcoal sufficiently for this to burn likewise, as you see is now the case.

Emily. I am surprised that the combustion of car bone is not more brilliant; it does not disengage near so much light or caloric as phosphorus, or sulphur. Yet, since it combines with so much oxygen, why is not a proportional quantity of light and heat disengaged from the decomposition of the oxygen gas?

Mrs. B. It is not surprising that less light and heat should be disengaged in this than in almost any other combustion, since the oxygen, instead of entering into a solid or a liquid combination, as it does in the phosphoric and sulphuric acids, is employed in forming another elastic fluid.

Emily. True; and, on second consideration, it appears, on the contrary, surprising that the oxygen should, in its combination with carbone, retain a sufficient portion of caloric to maintain both substances in a gaseous state.

Caroline. We may then judge of the degree of solidity in which oxygen is combined in a burnt body, by the quantity of caloric liberated during its combustion?

Mrs B. Yes; provided that you take into the account the quantity of oxygen absorbed by the combustible body, and observe the proportion which the caloric bears to it.

Caroline. But why should the water, after the combustion of carbone, rise in the receiver since the gas within it retains an aeriform state?

rs. B. Because carbonic acid gas is more dense, consequently occupies less space than oxygen gas; water therefore rises to fill the vacuum formed by liminution of volume of the gas.

aroline. That is very clear: and the condensation e new gas depends, I suppose, on the quantity of ic that has been disengaged.

rs. B. The gas must be decreased in volume, that circumstance, in a certain proportion; but nsity is still further increased by the addition of the ne. But besides this condensation, there is in our riment another cause of the diminution of volume, 1 is, that carbonic acid gas, by standing over wa- s gradually absorbed by it, an effect which is pro- l by shaking the receiver.

ily. The charcoal is now extinguished, though ot nearly consumed; it has such an extaordinary y for oxygen, I suppose, that the receiver did not n enough to satisfy the whole.

s. B. That is certainly the case; for if the com- n was performed in the exact proportions of 28 of carbone to 72 of oxygen, both these ingredi- vould disappear, and 100 parts of carbonic acid be produced.

oline. Carbonic acid must be a very strong acid, t contains so great a proportion of oxygen?

s. B. That is a very natural inference; yet it is ous. For the carbonic is the weakest of all the The strength of an acid seems to depend upon ture of its basis and its mode of combination, as s upon the proportion of the acidifying principle. ame quantity of oxygen that will convert some into strong acids, will only be sufficient simply to e others.

line. Since this acid is so weak, I think chem- ould have called it the *carbonous*, instead of the c acid.

ly. But, I suppose, the carbonous acid is still , and is formed by burning carbone in atmosphe- r.

. *B.* No, my dear. Carbone does not ap-

pear to be susceptible of more than one degree of acidification, whether burnt in oxygen gas, or atmospherical air. There is therefore no carbonous acid.

It has indeed been lately discovered, that carbone may be converted into a gas, by uniting with a smaller proportion of oxygen; but as this gas does not possess any acid properties, it is no more than an oxyd; and in order to distinguish it from charcoal, which contains a still smaller proportion of oxygen, it is called *gaseous oxyd of carbone*.

Caroline. Pray is not carbonic acid a very wholesome gas to breathe, as it contains so much oxygen?

Mrs. B. On the contrary, it is extremely pernicious. Oxygen, when in a state of combination with other substances, loses, in almost every instance, its respirable properties, and the salubrious effects which it has on the animal economy when in its uncombined state. Carbonic acid is not only unfit for respiration, but extremely deleterious if taken into the lungs.

Emily. You know, Caroline, how very unwholesome the fumes of burning charcoal are reckoned.

Caroline. Yes; but to confess the truth, I did not consider that a charcoal fire produced carbonic acid gas.—Pray, can this gas be condensed into a liquid?

Mrs. B. No: for, as I told you before, it is a permanent elastic fluid. But water can absord a certain quantity of this gas, and can even be impregnated with it, in a very strong degree, by the assistance of agitation and pressure, as I am going to show you. I shall decant some carbonic acid gas into this bottle, which I fill first with water, in order to exclude the atmospherical air; the gas is then introduced through the water, which you see it displaces, for it will not mix with it in any quantity unless strongly agitated, or allowed to stand over it for some time. The bottle is now about half full of carbonic acid gas, and the other half is still occupied by the water. By corking the bottle, and then violently shaking it, in this way, I can mix the gas and water together.—Now will you taste it?

Emily. It has a distinct acid taste.

Caroline. Yes, it is sensibly sour, and appears full

little bubbles.

Mrs. B. It possesses likewise all the other proper-
:s of acids, but of course in a less degree than the
ire carbonic acid gas, as it is so much diluted by wa-
r.

This is a kind of artificial Seltzer water. By analy-
ng that which is produced by nature, it was found to
ntain scarcely any thing more than common water
ipregnated with a certain proportion of carbonic acid
ts. We are, therefore, able to imitate it, by mixing
ose proportions of water, and carbonic acid. Here,
y dear, is an instance, in which, by a chemical pro-
ss, we can exactly copy the operations of nature; for
e artificial Seltzer waters can be made in every res-
ect similar to those of nature: in one point, indeed,
e former have an advantage, since they may be pre-
ared stronger, or weaker, as occasion requires.

Caroline. I thought I had tasted such water before.
ut what renders it so brisk and sparkling?

Mrs. B. This sparkling, or effervescence, as it is
illed, is always occasioned by the action of an elastic
uid escaping from a liquid; in the artifical Seltzer wa-
ir it is produced by the carbonic acid, which being
ghter than the water in which it was strongly conden-
ed, flies off with great rapidity the instant the bottle is
ncorked; this makes it necessary to drink it immedi-
ely. The bubbling that took place in this bottle was
ut trifling, as the water was but very slightly impreg-
ated with carbonic acid. It requires a particular ap-
aratus to prepare the gaseous artificial mineral waters.

Emily. If, then, a bottle of Seltzer water remains
or any length of time uncorked, I suppose it returns
o the state of common water?

Mrs. B. The whole of the carbonic acid gas, or very
early so, will soon disappear; but there is likewise in
Seltzer water a very small quantity of soda, and of a few
ther saline or earthy ingredients, which will remain
n the water, though it should be kept uncorked for any
ength of time.

Caroline. I have often heard of people drinking soda
water, pray what sort of water is that?

Mrs. B. It is a kind of a
ing in solution, besides the
saline substance, called soda
ter certain medicinal qualitie

Caroline. But how can
some, since carbonic acid is

Mrs. B. A gas we may
judicial to breathe, may be l
But it would be of no use to at
fully at present.

Caroline. Are waters ne
gasses?

Mrs. B. Yes; there ar
waters. I forgot to tell you
years past been prepared, i
gen and hydrogen gasses.
of nature, but are altogether
They have been lately use
abroad, where, I understan
reputation.

Emily. If I recollect rig
carbone was capable of dec
ity between oxygen and carb
ter than between oxygen an

Mrs. B. Yes; but this
temperature be raised to a
when carbone is red hot, t
ting the oxygen from the h
quantity of water be thrown
crease, rather than extingui
coals or wood (both of whic
of carbone) decompose the
fire both with oxygen and h
contrary, a large mass of w
the diminution of heat thu
combustible matter loses the
water, and the fire is exting

Emily. I have heard t
more harm than good, an
fire when they cannot
h it. It must be owi

ion of the water by the carbone during the confla-ion.

rs. B. Certainly.—The apparatus which you see (*Plate* VIII. *Fig*. 20.) may be used to exemplify t we have just said. It consists in a kind of open ace, through which a porcelain tube, containing coal, passes. To one end of the tube is adapted a s retort with water in it; and the other end com-nicates with a receiver placed on the water bath. A p being applied to the retort, and the water made boil, the vapour is gradually conveyed through the l hot charcoal, by which it is decomposed; and the drogen gas which results from this decomposition is llected in the receiver. But the hydrogen thus ob-ned is far from being pure; it retains in solution a inute portion of carbone, and contains also a quantity carbonic acid. This renders it heavier than pure drogen gas, and gives it some peculiar properties: is distinguished by the name of *carbonated hydrogen s.*

Caroline. And whence does it obtain the carbonic d that is mixed with it?

Emily. I believe I can answer that question, Carol-.—From the union of the oxygen (proceeding from decomposed water) with the carbone, which, you ow, makes carbonic acid.

Caroline. True; I should have recollected that.—e product of the decomposition of water by red hot arcoal, therefore, is carbonated hydrogen gas and bonic acid gas.

Mrs. B. You are perfectly right now.

arbone is frequently found combined with hydrogen a state of solidity, especially in coals, which owe ir combustible nature to these two principles.

Emily. Is it the hydrogen, then, that produces the me of coals?

Mrs. B. It is so; and when all the hydrogen is nsumed, the carbone continues to burn without me. But again the hydrogen gas produced by the mbustion of coals is not pure; for, during the com-stion, particles of carbone are successively volatilized

with the hydrogen, with which they form what i
a *hydro-carbonate*, which is the essential combust

Carbone is a very bad conductor of heat; f
reason it is employed (in conjunction with other i
ents) for coating furnaces and other chemical ap

Emily. Pray what is the use of coating furn

Mrs. B. In most cases, in which a furnace
it is necessary to produce and preserve a great
of heat, for which purpose every possible me
used to prevent the heat from escaping by com
ting with other bodies, and this object is atta
coating over the inside of the furnace with a
plaster, composed of materials that are bad co
of heat.

Carbone combined with a small quantity of iro
a compound called plumbago, or black lead, o
pencils are made. This substance, agreeabl
nomenclature, is *a carburet of iron*.

Caroline. Why, then, is it called black lead

Mrs. B. I really cannot say; but it is certainl
improper name for it, as there is not a particl
in the composition. There is another carbure
though united only to an extremely small pr
of carbone, acquires very remarkable properti
is steel.

Caroline, Really; and yet steel is much har
iron?

Mrs. B. But carbone is not ductile, like i
therefore may render the steel more brittle,
vent its bending so easily. Whether it is that
bone by introducing itself into the pores of
and by filling them, makes the metal both ha
heavier; or whether this change depends up
chemical cause, I cannot pretend to decide.
is a subsequent operation, by which the har
steel is very much increased, which simply c
heating the steel till it is red hot, and then pl
into cold water.

Carbone besides the combination just menti
ters into the composition of a vast number c
productions, such, for instance, as all the vario

of oils, which result from the combination of carbone, hydrogen, and caloric, in various proportions.

Emily. I thought that carbone, hydrogen, and caloric, formed carbonated hydrogen gas?

Mrs. B. That is the case when a small portion of carbonic acid gas is held in solution by hydrogen gas. Different proportions of the same principles, together with the circumstances of their union, produce very different combinations; of this you will see innumerable examples. Besides we are not now talking of gasses, but of carbone and hydrogen, combined only with a quantity of caloric sufficient to bring them to the consistency of oil or fat.

Caroline. But oil and fat are not of the same consistence?

Mrs. B. Fat is only congealed oil; or oil, melted fat. The one requires a little more heat to maintain it in a fluid state, than the other. Have you never observed the fat of meat turned to oil by the caloric it has imbibed from the fire?

Emily. Yet oils in general, as salad oil, and lamp oil, do not turn to fat when cold?

Mrs. B. Not at the common temperature of the atmosphere, because they retain too much caloric to congeal at that temperature; but if exposed to a sufficient degree of cold, their latent heat is extricated, and they become solid fat substances. Have you never seen salad oil frozen in winter?

Emily. Yes; but it appears to me in that state very different from animal fat.

Mrs. B. The essential constituent parts of either vegetable or animal oils are the same, carbone and hydrogen; their variety arises from the different proportions of these substances, and from other accessary ingredients that may be mixed with them. The oil of a whale, and the oil of roses, are, in their essential constituent parts, the same; but the one is impregnated with the offensive particles of animal matter, the other with the delicate perfume of a flower.

The difference of *fixed oils*, and *volatile* or *essential oils*, consist also in the various proportions of carbone

Emily. When you say that one kind of orate, and the other be decomposed, you pose, by the application of heat?

Mrs. B. Not necessarily; for there will evaporate slowly at the common te the atmosphere; but for a more rapid vol for their decomposition, the assistance o quired.

Caroline. I shall now remember, I tl and oil are really the same substances, co of carbone and hydrogen; that in fixed bone preponderates, and heat produces a tion; while, in essential oils, the proport gen is greater, and heat produces volatiliz

Emily. I suppose the reason why oil in lamps, is because its two constituents bustible?

Mrs. B. Certainly; the combustion the same as that of a candle; if tallow, in a concrete state; if wax, or spermac chemical ingredients are still hydrogen an

Emily. I wonder, then, there should b difference between tallow and wax?

Mrs. B. I must again repeat that the sa

a candle, and that of a lamp, both produce water and carbonic acid gas. Can you tell me how these are formed?

Emily. Let me think . . . . Both the candle and lamp burn by means of fixed oil—this is decomposed as the combustion goes on; and the constituent parts of the oil being thus separated, the carbone unites to a portion of oxygen from the atmosphere to form carbonic acid gas, whilst the hydrogen combines with another portion of oxygen, and forms with it water. The products therefore, of the combustion of oils, are water and carbonic acid gas.

Caroline. But we see neither water nor carbonic acid produced by the combustion of a candle?

Mrs. B. The carbonic acid gas, you know is invisible, and the water being in a state of vapour, is so likewise. Emily is perfectly correct in her explanation, and I am very much pleased with it.

All the vegetable acids consist of various proportions of carbone and hydrogen, acidified by oxygen. Gums, sugar, and starch, are likewise composed of these ingredients; but as the oxygen which they contain is not sufficient to convert them into acids, they are classed with the oxyds, and called vegetable oxyds.

Emily. I am very much delighted with all these new ideas; but at the same time, I cannot help being apprehensive that I may forget many of them.

Mrs. B. I would advise you to take notes, or, what would answer better still, to write down, after every lesson, as much of it as you can recollect. And, in order to give you a little assistance, I shall lend you the heads or index, which I occasionally consult for the sake of preserving some method and arrangement in these conversations. Unless you follow some such plan, you cannot expect to retain nearly all that you learn, how great soever be the impression it may make on you at first.

Emily. I will certainly follow your advice.—Hitherto I have found that I recollected pretty well what you have taught us; but the history of carbone is a more

Mrs. B. Certainly; it is the basis, you l
of all vegetable matter; and you will find
very essential to the process of animalization
the mineral kingdom also, particularly in it
carbonic acid, we shall often discover it comb
a great variety of substances.

In chemical operations, carbone is partic
ful, from its very great attraction for oxygen,
absorb this substance from many oxygenate
bodies, and thus deoxygenate, or *unburn* t
restore them to their original combustible sta

Caroline. I do not understand how a bod
unburnt, and restored to its original state. T
of tinder, for instance, that has been burnt,
means the oxygen was extracted from it, wou
restored to its former state of linen; for its t
destroyed by burning, and that must be the
all organized or manufactured substances, a
served in a former conversation.

Mrs. B. A compound body is decompose
bustion, in a way which generally precludes
bility of restoring it to its former state; the ox
instance, does not become fixed in the tin
combines with its volatile parts, and flies

shall say nothing further of this at present, as the metals will furnish ample subject for another morning; and they are the class of simple bodies that come next under our consideration.

Conversation IX.

On Metals.

Mrs. B.

The metals, which we are now to examine, are bodies of a very different nature from those which we have hitherto considered. They do not, like the elements of gasses, elude the immediate observation of our senses: for they are the most brilliant, the most ponderous, and the most palpable substances in nature.

Caroline. I doubt, however, whether the metals will appear to us so interesting, and give us so much entertainment as those mysterious elements which conceal themselves from our view. Besides, they cannot afford so much novelty; they are bodies with which we are already so well acquainted.

Mrs. B. But the acquaintance, you will soon perceive, is but very superficial; and I trust that you will find both novelty and entertainment in considering the metals in a chemical point of view. To treat of this subject fully, would require a whole course of lectures; for metals form of themselves a most important branch of practical chemistry. We must, therefore, confine ourselves to a general view of them. These bodies are seldom found naturally in their metallic form; they are generally more or less oxygenated or combined with sulphur, earths, or acids, and are often blended with each other. They are found buried in the bowels of

the earth in most parts of the globe, but chiefly in mountainous districts, where the surface of the globe has suffered from earthquakes, volcanoes, and other convulsions of nature. They are there spread in strata or beds, called veins, and these veins are composed of a certain quantity of metal, combined with various earthy substances, with which they form minerals of different nature and appearance, which are called ores.

Caroline. I am now amongst old acquaintance, for my father has a lead mine in Yorkshire, and I have heard a great deal about veins of ore, and of the *roasting* and *smelting* of the lead; but, I confess, that I do not understand in what these operations consist.

Mrs. B. Roasting is the process by which the volatile parts of the ore are evaporated; smelting, that by which the pure metal is afterwards separated from the earthy remains of the ore. This is done by throwing the whole into a furnace, and mixing with it certain substances, that will combine with the earthy parts, and other foreign ingredients of the ore; the metal being the heaviest, falls to the bottom, and runs out by proper openings, in its pure metallic state.

Emily. You told us in a preceding lesson that metals had a strong affinity for oxygen. Do they not, therefore, combine with oxygen, when strongly heated in the furnace, and run out in the state of oxyds?

Mrs. B. No; for the scoriæ, or oxyd, which soon forms on the surface of the fused metal, when it is oxydable, prevents the air from having any further influence on the mass; so that neither combustion nor oxygenation can take place.

Caroline. Are all the metals combustible?

Mrs. B. Yes, without exception; but their attraction for oxygen varies extremely: there are some that will combine with it only at a very high temperature, or by the assistance of acids; whilst there are others that oxydate of themselves very rapidly, even at the lowest temperature, as manganese, which scarcely ever exists in its metallic state, as it immediately absorbs oxygen on being exposed to the air, and crumbles to an oxyd in the course of a few hours.

/. Is it not from that oxyd that you extracted gen gas ?

B. It is; so that, you see, this metal attracts at a low temperature, and parts with it when heated.

/. Is there any other metal that oxydates at the ture of the atmosphere ?

B. They all do, more or less, excepting gold, nd platina.

er, lead, and iron, oxydate slowly in the air, and emselves with a sort of rust, a process which on the gradual conversion of the surface into l. This rusty surface preserves the interior om oxydation, as it prevents the air from com-ontact with it. Strictly speaking, however, the st applies only to the oxyd, which forms on the of iron, when exposed to air and moisture, xyd appears to be united with a small portion of c acid.

/. When metals oxydate from the atmosphere an elevation of temperature, some light and suppose, must be disengaged, though not in it quantities to be sensible.

B. Undoubtedly; and, indeed, it is not sur-that in this case the light and heat should not ible, when you consider how extremely slow, leed, how imperfectly, most metals oxydate e exposure to the atmosphere. For the quan-oxygen with which metals are capable of com-generally depends upon their temperature; absorption stops at various points of oxydation, ng to the degree to which their temperature is

y. That seems very natural; for the greater ntity of caloric introduced into a metal, the fur-particles are separated from one another, and re easily, therefore, can they attract the oxy-l combine with it.

B. Certainly; and besides, in proportion as istance diminishes on one hand, the affinity in-on the other. When the metal oxygenates

with sufficient rapidity for light and heat to become s sible, combustion actually takes place. But this h pens only at very high temperatures, and the prod is nevertheless an oxyd; for though, as I have just s metals will combine with different proportions of o gen, yet, with the exception of only five of them, t are not susceptible of acidification.

Metals change colour during the different degree oxydation which they undergo. Lead, when heated contact with the atmosphere, first becomes grey; i temperature be then raised, it turns yellow, and a stronger heat changes it to red. Iron becomes suc sively a green, brown, and white oxyd. Copper chan from brown to blue, and lastly green.

Emily. Pray, is the white lead with which ho are painted prepared by oxydating lead?

Mrs. B. Yes; almost all the metallic oxyds used as paints. Red lead is another oxyd of that tal. The various sorts of ochres chiefly consist of more or less oxydated. And it is a remarkable cir stance, that if you burn metals rapidly, the lig flame they emit during combustion partakes c colours which the oxyd successively assumes.

Caroline. How is that accounted for, Mrs. B. light, you know, does not proceed from the bu body, but from the decomposition of the oxyger I hope you have a satisfactory answer to give m I am under some apprehensions for my favourite ry of combustion; and for the world I would no it overthrown.

Mrs. B. Do not be alarmed, my dear; I think it was ever supposed to be in danger from tl cumstance. The correspondence of the colour light with that of the oxyd which emits it, is, probability, owing to some particles of the metal are volatilized and carried off by the caloric.

Caroline. It is then a sort of metallic gas.

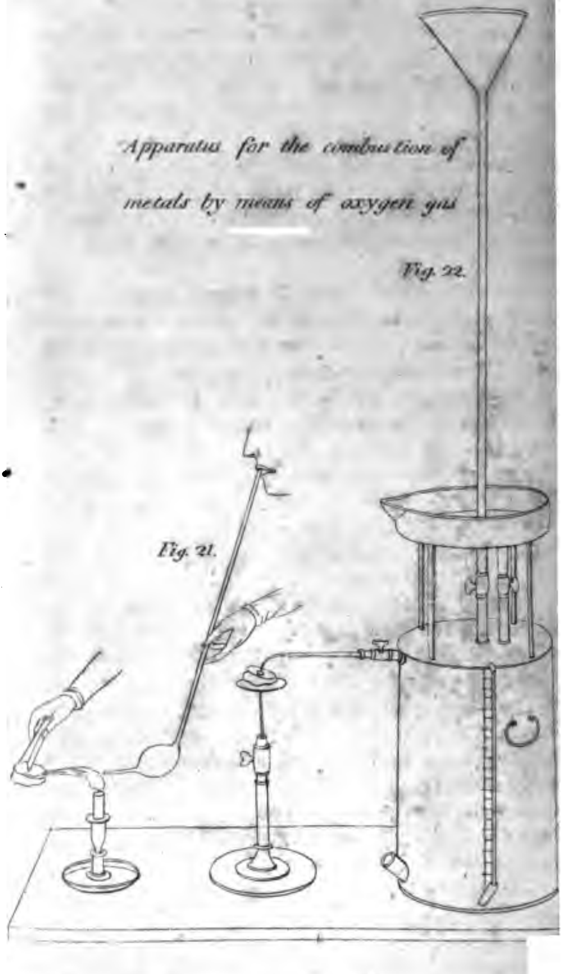
Emily. Why is it reckoned so unwholeso breath the air of a place in which metals are mel

Mrs. B. For this double reason, that most in melting oxydate more or less at their surfac

Apparatus for the combustion of metals by means of oxygen gas

Fig. 22.

Fig. 21.



...by the Author

Engraved for Increase Cooke & C°. New H...

r diminish the purity of the air; but more es-
r because the particles of the oxyd that are vola-
by the heat, and breathed with the air of the
re very noxious. This is particularly the case
ad and arsenic. Besides the large furnaces that
uired for these fusions, contribute also materially
the salubrity of the air in those places where
cess is carried on.

ist shew you some instances of the combustion
als; it would require the heat of a furnace to
hem burn in the common air, but if we supply
ith a stream of oxygen gas, we may easily ac-
sh it.

line. But it will still, I suppose, be necessary
e degree to raise their temperature; for the oxy-
ll not be able to penetrate such dense substances,
the.: aloric forces a passage for it.

. B. This, as you shall see, is very easily done,
larly if the experiment be tried upon a small
–I begin by lighting this piece of charcoal with
idle, and then increase the rapidity of its com-
by blowing upon it with a blow-pipe. (*Plate*
ig. 21.)

ly. That I do not understand; for it is not eve-
l of air, but merely oxygen gas, that produces
stion. Now you said that in breathing we in-
but did not expire, oxygen gas. Why, there-
hould the air which you breathe through the
ipe, promote the combustion of the charcoal?

. B. Because the air, which has but once pass-
ugh the lungs, is yet but little altered, a small
only of its oxygen being destroyed; so that a
leal more is gained by increasing the rapidity of
rent, by means of the blow-pipe, than is lost in
uence of the air passing once through the lungs,
shall see—

PLATE IX.

1. Igniting charcoal with a taper and blow-pipe. Fig.
nbustion of metals by means of a blow-pipe conveying a
of oxygen gas from a gas-holder.

Emily. Yes, indeed; it makes the charcoal much brighter.

Mrs. B. Whilst it is red hot, I shall drop som filings on it, and supply them with a current of o gas, by means of this apparatus (*Plate* IX. *Fig* which consits simply of a closed tin cylindrical full of oxygen gas, with two apertures and stop by one of which a stream of water is thrown int vessel through a long funnel, whilst by the oth gas is forced out through a blow-pipe adapted to the water gains admittance.—Now that I pour into the funnel, you may hear the gas issuing fro blow pipe—I bring the charcoal close to the cu and drop the filings upon it.—

Caroline. They emit much the same vivid lig the combustion of the iron wire in oxygen gas.

Mrs. B. The process is, in fact, the same; is only some difference in the mode of conduct Let us burn some tin in the same manner—y that it is equally combustible–Let us now try som per—

Caroline. This burns with a greenish flame; suppose, owing to the colour of the oxyd?

Emily. Pray, shall we not also burn some g

Mrs. B. That is not in our power, at least way. Gold, silver, and platina, are incapable c oxydated by the greatest heat that we can produc common method. It is from this circumstan they have been called perfect metals. Even these ver, have an affinity for oxygen; but their oxyd combustion can only be performed by means tricity. The spark given out by the Galvanic P duces in the point of contact a greater degree than any other process; and it is at this very hi perature only that the affinity of these metals for will enable them to act on each other.

I am sorry that I cannot shew you the combu the perfect metals by this process, but it require siderable Galvanic Battery. You will, howeve these experiments performed in the most perfe

n you attend the chemical lectures of the Roy-
tion.

ie. I think you said that the oxyds of metals
restored to their metallic state ?

B. Yes; this is called *reviving* a metal. Me-
in general capable of being revived by char-
en heated red hot, charcoal having, at that
ure, a greater attraction for oxygen than the
You need only therefore, decompose, or un-
oxyd, by depriving it of its oxygen, and the
ll be restored to its pure state.

But will the carbone, by this operation, be
id be converted into carbonic acid ?

B. Certainly. There are other combustible
es to which metals at a high temperature will
their oxygen. They will also yield it to each
cording to their several degrees of attraction
nd if the oxygen goes into a more dense state
tal which it enters, than it existed in that which
a proportional disengagement of caloric will
e.

ie. And cannot the oxyds of gold, silver, and
which are formed by means of the electric
restored to their metallic state ?

B. Yes, they may ; but the intervention of a
ble body is not required ; heat alone will take
en from them, convert it into a gas, and revive
l.

You said that rust was an oxyd of iron ; how
n, that water, or merely dampness, produces
, you know, it very frequently does on steel
or any iron instruments.

B. In that case the metal decomposes the
r dampness (which is nothing but water in a
apour), and obtains the oxygen from it.

e. I thought that it was necessary to bring me-
ery high temperature to enable them to decom-
er.

B. It is so, if it is required that the process
e performed rapidly, and if any considerable
is to be decomposed. Rust you know is some-

water, is there no sensible disengagement
heat?

Mrs. B. No; because the oxygen exis
a dense state in water; and the portion of
it parts with combines with the hydrogen t
into a gas.

Emily. Are all metals capable of decomp
provided their temperature be sufficiently r

Mrs. B. No; a certain degree of attr
quisite, besides the assistance of heat. W
collect, is composed of oxygen and hyd
unless the affinity of the metal for oxygen
than that of hydrogen, it is in vain that
temperature, for it cannot take the oxyge
hydrogen. Iron, zinc, tin, and antimony, h
er affinity for oxygen than hydrogen h
these four metals are capable of decomp
But hydrogen having an advantage over
metals with respect to its affinity for oxyge
withholds its oxygen from them, but is
in certain circumstances, of taking the o
the oxyd of these metals.

Emily. I confess that I do not quite und
hydrogen can take oxygen from those m
not decompose water.

same with all the other metals which do not de-
ose water.

ily. I understand your explanation, Caroline-
vell; and I imagine that it is because lead can,
compose water that it is so much employed for
for conveying that fluid.

s. B. Certainly; lead is, on that account, par-
rly appropriate to such purposes; whilst, on the
ry, this metal, if it was oxydable by water, would
t to it very noxious qualities, as all oxyds of lead
ore or less pernicious.

, with regard to the oxydation of metals, there
ode of effecting it more powerful than either or
rmer, which is by means of acids. These, you
contain a much greater proportion of oxygen
ither air or water; and will, most of them, easi-
ld it to metals. Have you never observed, that if
rop vinegar, lemon, or any acid, on the blade of
e, or on a pair of scissars, it will immediately pro-
a spot of rust.

roline. Yes, often; and I am very careful now
e off the acid immediately to prevent the rust
forming.

ily. Metals have, then, three ways of obtaining
en; from the atmosphere, from water, and from

rs. B. The two first you have already witnessed,
shall now show you how metals take the oxygen
an acid. This bottle contains nitric acid; I shall
some of it over this piece of copper-leaf . . . . .

roline. Oh, what a disagreeable smell!

ily. And what is it that produces the efferves-
and that thick yellow vapour?

rs. B. It is the acid, which being abandoned by
greatest part of its oxygen, is converted into a
er acid, which escapes in the form of gas.

roline. And whence proceeds this heat?

rs. B. Indeed, Caroline, I think you might now
le to answer that question yourself.

roline. Perhaps it is that the oxygen enters into

nection between metals and acids, with wi
make you acquainted. Metals when in t
oxyds, are capable of being disolved by ac
operation they enter into a chemical comb
the acid, and form an entirely new compou

Caroline. But what difference is there b
oxydation and the *dissolution* of a metal by a

Mrs. B. In the first case, the metal m
bines with a portion of oxygen taken fro
which is thus partly deoxygenated, as in t
you have just seen; in the second case, the
being previously oxydated, is actually diss
acid, and enters into a chemical combina
without producing any further decompositi
vescence.—This complete combination of a
an acid forms a peculiar and important cla
pound salts.

Emily. The difference between an oxyd
pound salt, therefore, is very obvious: the
of a metal and oxygen; the other of an ox

Mrs. B. Very well: and you will be ca
member that the metals are incapable of e
this combination with acids, unless they are
oxydated; therefore, whenever you bring
contact with an acid, it will be first oxydated
wards dissolved, provided that there be

to act upon: then other coats of oxyd are successively formed, and rapidly dissolved by the acid, which continues combining with the new-formed surfaces of the oxyd till the whole of the metal is dissolved. During this process the hydrogen gas of the water is disengaged and flies off with effervescence.

Emily. Was not this the manner in which the sulphuric acid assisted the iron filings in decomposing water?

Mrs. B. Exactly; and it is thus that several metals, which are incapable alone of decomposing water, are enabled to do it by the assistance of an acid, which, by continually washing off the covering of oxyd, as it is formed, prepares a fresh surface of metal to act upon the water.

Caroline. The acid here seems to act a part not very different from that of a scrubbing-brush.—But pray would not this be a good method of cleaning grates and metallic utensils?

Mrs. B. You forget that acids have the power of oxydating metals, as well as that of dissolving their oxyds; so that by cleaning a grate in this way, you would create more rust than you could destroy.

Caroline. True; how thoughtless I was to forget that! Let us watch the dissolution of the copper in the nitric acid; for I am very impatient to see the salt that is to result from it. The mixture is now of a beautiful blue colour; but there is no appearance of the formation of a salt; it seems to be a tedious operation.

Mrs. B. The crystallization of the salt requires some length of time to be completed; if, however, you are so impatient, I can easily shew you a metallic salt already formed.

Caroline. But that would not satisfy my curiosity half so well as one of our own manufacturing.

Mrs. B. It is one of our own preparing that I mean to shew you. When we decomposed water a few days since, by the oxydation of iron filings, through the assistance of sulphuric acid, in what did the process consist?

Caroline. In proportion as the water yielded its oxygen to the iron, the acid combined with the new-formed oxyd, and the hydrogen escaped alone.

Mrs. B. Very well: the result, therefore, was a compound salt, formed by the combination of sulphuric acid with oxyd of iron. It still remains in the vessel in which the experiment was performed. Fetch it, and we shall examine it.

Emily. What a variety of processes the decomposition of water, by a metal and an acid, implies! 1st, The decomposition of the water; 2dly, the oxydation of the metal; and 3dly, the formation of a compound salt.

Caroline. Here it is, Mrs. B.—What beautiful green crystals! But we do not perceive any crystals in the solution of copper in nitrous acid?

Mrs. B. Because the salt is now suspended in the water which the nitrous acid contains, and will remain so till it is deposited in consequence of rest and cooling.

Emily. I am surprised that a body so opaque as iron can be converted into such transparent crystals.

Mrs. B. It is the union with the acid that produces the transparency; for if the pure metal was melted, and afterwards permitted to cool and crystallize, it would be found just as opaque as before.

Emily. I do not understand the exact meaning of *crystallization?*

Mrs. B. You recollect that when a solid body is dissolved either by water or caloric, it is not decomposed; but that its integrant parts are only suspended in the solvent. When the solution is made in water, the integrant particles of the body will, on the water being evaporated, again unite into a solid mass, by the force of their mutual attraction. But when the body is dissolved by caloric alone, nothing more is necessary, in order to make its particles reunite, than to reduce its temperature. And, in general, if the solvent, whether water or caloric, be slowly separated by evaporation or by cooling, and care taken that the particles be not agitated during their reunion, they will arrange them-

selves in regular masses, each individual substance assuming a peculiar form or arrangement; and that is what is called crystallization.

Emily. Crystallization, therefore, is simply the reunion of the particles of a solid body that has been dissolved in a fluid.

Mrs. B. That is a very good definition of it. But I must not forget to observe, that *heat* and *water* may unite their solvent powers; and in this case, crystallization may be hastened by cooling, as well as by evaporating the liquid.

Caroline. But if the body dissolved be of a volatile nature, will it not evaporate with the fluid?

Mrs. B. A crystallizable body, held in solution only by water, is scarcely ever so volatile as the fluid itself, and care must be taken to manage the heat, so that it may be sufficient to evaporate the water only.

I should not omit to mention that bodies, in crystallizing from their watery solution, always retain a small portion of water, which remains confined in the crystal in a solid form, and does not reappear, unless the body loses its crystalline state. This is called the *water of crystallization.*

It is also necessary that you should here more particularly remark the difference, to which we have formerly alluded, between the simple solution of bodies either in water or in caloric, and the solution of metals in acids; in the first case, the body is merely divided by the solvent into its minutest parts. In the latter, a similar effect is, indeed, produced; but it is by means of a chemical combination between the metal and the acid, in which both lose their characteristic properties. The first is a mechanical operation, the second a chemical process. We may, therefore, distinguish them by calling the first a *simple solution*, and the other a *chemical solution.* Do you understand this difference?

Emily. Yes; *simple solution* can affect only the attraction of aggregation. But *chemical solution* implies also an attraction of composition, that is to say, an actual combination between the solvent and the body dissolved.

Mrs. B. You have expressed your idea very well indeed. But you must observe, also, that whilst a body may be separated from its solution in water or caloric, simply by cooling or by evaporation, an acid can be taken from a metal with which it is combined, only by stronger affinities, which produce a decomposition.

Emily. I think that you have rendered the difference between these two kinds of solution so obvious, that we can never confound them.

Mrs. B. Notwithstanding, however, the real difference which there appears to be between these two operations, they are frequently confounded. Indeed, several modern chemical writers, of great eminence, have even thought proper to generalize the idea of solution, and to suppress entirely the distinction introduced by the great Lavoisier, which I have taken so much pains to explain, and which I confess appears to me to render the subject much clearer.

Emily. Are the perfect metals susceptible of being dissolved and converted into compound salts by acids?

Mrs. B. Gold is acted upon by only one acid, the *oxygenated muriatic*, a very remarkable acid, which, when in its most concentrated state, dissolves gold or any other metal, by burning them rapidly.

Gold can, it is true, be dissolved likewise by a mixture of two acids, commonly called *aqua regia;* but this mixed solvent derives that property from containing the peculiar acid which I have just mentioned. Platina is also acted upon by this acid only; but silver is dissolved by several of them—

Caroline. I think you said that some of the metals might be so strongly oxydated as to become acid?

Mrs. B. There are five metals, arsenic, molybdena, chrome, tungsten, and columbium,* which are susceptible of combining with a sufficient quantity of oxygen to be converted into acids.

Caroline. Acids are connected with metals in such a variety of ways, that I am afraid of some confusion in

* Columbium, which has not long ſince been diſcovered by Mr. Hatchett, was inadvertently omitted in the enumeration of the simple bodies given in the firſt converſation.

embering them.—In the first place, acids will yield r oxygen to metals. Secondly, they will combine them in their state of oxyds, to form compound ; and lastly, several of the metals are themselves eptible of acidification.

rs. B. Very well; but though metals have so t an affinity for acids, it is not with that class of bo- alone that they will combine. They are most of n in their simple state, capable of uniting with sul-, with phosphorus, with carbone, and with each r; these combinations, according to the nomen- re which was explained to you on a former occa- are called *sulphurets*, *phosphorets*, *carburets*, &c.

he metallic phosphorets offer nothing very re- able. The sulphurets form the peculiar kind of ral called *pyrites*, from which certain kinds of mi- waters, as those of Harrogate, derive their chief ical properties. In this combination, the sulphur, ther with the iron, have so strong an attraction for en, that they obtain it both from the air and from r, and by condensing it in a solid form, produce eat which raises the temperature of the water in a remarkable degree.

nily. But if pyrites obtain oxygen from water, water must suffer a decomposition, and hydrogen e evolved?

rs. B. That is actually the case in the hot springs ed to, which give out an extremely fetid gas, osed of hydrogen impregnated with sulphur.

roline. If I recollect right, steel and plumbago, h you mentioned in the last lesson, are both car- s of iron?

rs. B. Yes; and they are the only carburets of n consequence.

curious combination of metals has lately very much ted the attention of the scientific world: I mean tones that fall from the atmosphere. They all st principally of native or pure iron which is never ed in that state in the bowels of the earth; and in also a small quantity of nickle and chrome, a ination likewise new in the mineral kingdom.

These circumstances have led many scientific persons to believe that those substances have fallen from the moon or some other planet, while others are of opinion either that they are formed in the atmosphere, or are projected into it by some unknown volcano on the surface of our globe.

Caroline. I have heard much of these stones, but I believe many people are of opinion that they are formed on the earth, and laugh at their pretended celestial origin.

Mrs. B. The fact of their falling is so well ascertained, that I think no person who has at all investigated the subject, can now entertain any doubt of it. Specimens of these stones have been discovered in all parts of the world, and to each of them has some tradition or story of its fall been found connected. And as the analysis of all the specimens affords precisely the same results, we have thus a very strong proof that they all proceed from the same source. It is to Mr. Howard that philosophers are indebted, for having first analysed these stones, and directed their attention to this interesting subject.

But we must not suffer this digression to take up too much of our time.

The combinations of metals with each other are called alloys; thus brass is an alloy of copper and zinc; bronze, of copper and tin, &c.

Emily. And is not pewter also a combination of metal?

Mrs. B. It is. The pewter made in this country is mostly composed of tin, with a very small proportion of zinc and lead.

Caroline. Block-tin is a kind of pewter, I believe?

Mrs. B. No; it is iron plated with tin, which renders it more durable, as tin will not so easily rust. Tin alone, however, would be too soft a metal to be worked for common use, and all the tin vessels or utensils are in fact made of plates of iron thinly coated with tin, which prevents the iron from rusting.

Caroline. Say rather *oxydating*, Mrs. B.—Rust is a word that should be exploded in chemistry.

ie. Is it possible that oxygen can impart poi-
|ualities ? That valuable substance which pro-
ht, and fire, and which all bodies in nature are
to obtain !

B. Most of the metallic oxyds are poisonous,
'e this property from their union with oxygen.
te lead, so much used in paint, owes its per-
ffects to oxygen. In general oxygen, in a con-
te, appears to be particularly destructive in its
ı flesh or any animal matter ; and those oxyds
caustic that have an acrid burning taste, which
from the metal having but a slight affinity for
and therefore easily yielding it to the flesh
corrodes and destroys.

What is the meaning of the word *caustic*,
u have just used ?

3. It expresses that property which some
ossess, of disorganizing and destroying animal
oy operating a kind of combustion, or at least
al decomposition. You must often have heard
s used to burn warts, or other animal excrescen-
st of these bodies owe their destructive power
ygen with which they are combined. The
caustic, called *lunar caustic*, is a compound
y the union of nitric acid and silver ; and it is
l to owe its caustic qualities to the oxygen con-
the nitric acid.

ie. But, pray, are not acids still more caus-
oxyds, as they contain a greater proportion of

3. Some of the acids are*; but the caustic
of a body depends not only upon the quantity
n which it contains, but also upon its slight
or that principle, and the consequent facility
ch it yields it.

. Is not this destructive property of oxygen
d for ?

B. It proceeds probably from the strong at-
of oxygen for hydrogen ; for if the one rapid-
s the other from the animal fibre, a disorgani-
the substance must ensue.

Emily. Caustics are then very properly said to bu the flesh, since the combination of oxygen and hyd gen is an actual combustion.

Caroline. Now, I think, this effect would be m properly termed an oxydation, as there is no diseng ment of light and heat.

Mrs. B. But there really is a sensation of heat duced by the action of caustics; and the caloric th disengaged must, I think, partly, if not wholly, ceed from the oxygen which the caustic yields t flesh.

Caroline. Yet the oxygen of a caustic is n gaseous state, and can therefore have no caloric t with?

Mrs. B. In whatever state oxygen exists, w suppose that, like every other body in nature, tains some portion of caloric; and if, in com with the hydrogen of the flesh, it becomes more than it previously was in the caustic, it must pa caloric whilst this change is taking place. I be have once before observed that we may, in a gre sure, judge of the comparative degree of which oxygen assumes in a body, by the qua caloric liberated during its combination; and w find, that, in its passage from one body to anoth is evolved, we may be certain that it exists in solid state in the latter.

Emily. But if oxygen is so caustic, why d that contained in the atmosphere burn us?

Mrs. B. Because it is in a gaseous state, an greater attraction for its caloric than for the hyd our bodies. Besides, should the air be slight tic, we are in a great measure sheltered from it by the skin; you all know how much a wound, er trifling, smarts on being exposed to it.

Caroline. It is a curious idea, however, should live in a slow fire. But, if the air was would it not have an acrid taste?

Mrs. B. It possibly might have such a taste; in so slight a degree, that custom has rendered sible.

line. And why is not water caustic? When I
hand into water, though cold, it ought to burn
m the caustic nature of its oxygen.

B. Your hand does not decompose the water;
ygen in that state is much better supplied with
en than it would be by animal matter, and if its
ity depend on its affinity for that principle, it will
far from quitting its state of water to act upon
and. You must not forget that oxyds are caustic
ortion as the oxygen adheres slightly to them.

ly. Since the oxyd of arsenic is poisonous, its
suppose, is fully as much so?

B. Yes; it is one of the strongest poisons in

ly. There is a poison called *verdigris*, which
n brass and copper when not kept very clean;
s, I have heard, is an objection to these metals
nade into kitchen utensils. Is this poison like-
casioned by oxygen?

B. It is produced by the intervention of oxy-
for verdigris is a compound salt formed by the
f vinegar and copper; it is of a beautiful green
and much used in painting.

ly. But, I believe, verdigris is often formed on
when no vinegar has been in contact with it.

B. Not real verdigris, but compound salts,
hat resembling it, may be produced by the ac-
any acid on copper.

re is a beautiful green salt produced by the com-
n of cobalt with muriatic acid, which has the
r property of forming what is called *sympathetic*
Characters written with this solution are invisible
old, but when a gentle heat is applied, they as-
fine blueish green colour.

line. I think one might draw very curious land-
with the assistance of this ink; I would first make
r colour drawing of a winter scene, in which the
hall be leafless and the grass scarcely green; I
then trace all the verdure with the invisible ink,
enever I chose to create spring, I should hold

it before the fire, and its warmth would cover the landscape with a rich verdure.

Mrs. B. That will be a very amusing experiment, and I advise you by all means to try it.—I must now, however, take my leave of you; we have had a very long lecture, and I hope you will be able to remember it. Do not forget to write down all you can recollect of this conversation, for the subject is of great importance, though it may not appear at first very entertaining.

Conversation X.

On Alkalies.

Mrs. B.

After having taken a general view of combustible bodies, we now come to the ALKALIES, and the EARTHS, which compose the class of incombustibles; that is to say, of such bodies as do not combine with oxygen at any known temperature.

Caroline. I am afraid that the incombustible substances will not be near so interesting as the others; for I have found nothing in chemistry that has pleased me so much as the theory of combustion.

Mrs. B. Do not however depreciate the incombustible bodies before you are acquainted with them; you will find they also possess properties highly important and interesting.

Some of the earths bear so strong a resemblance in their properties to the alkalies, that it is a difficult point to know under what head to place them. The celebrated French chemist, Fourcroy, has classed two of them

tes and Strontites) with the alkalies; but, as lime agnesia have almost an equal title to that rank, I it better not to separate them, and therefore have ed the common method of classing them with the , and of distinguishing them by the name of *alkarths.*

shall first take a review of the alkalies, of which are three species: POTASH, SODA, and AMMONIA. wo first are called *fixed alkalies*, because they ex- a solid form at the temperature of the atmosphere, quire a great heat to be volatilized. The third, onia, has been distinguished by the name of *volaali*, because its natural form is that of gas.

roline. Ammonia? I do not recollect that name list of simple bodies.

s. B. The reason why you do not find it there is, is a compound; and if I introduce it to your ac- tance now, it is on account of its close connec- ith the two other alkalies, which it resembles es- lly in its nature and properties. Indeed it is not since ammonia has resigned its place among the e bodies, as it was not, till lately, supposd to be a ound; nor is it improbable that potash and soda ome day undergo the same fate, as they are strong- pected of being compounds also.

e general properties of alkalies are, an acrid ng taste, a pungent smell, and a caustic action on in and flesh.

roline. How can they be caustic, Mrs. B. since do not contain oxygen?

rs. B. Whatever substance has an affinity for any f the constituents of animal matter, sufficiently rful to decompose it, is entitled to the appellation ustic. The alkalies, in their pure state, have a strong attraction for water, for hydrogen, and for ne, which, you know, are the constituent princi- of oil, and it is chiefly by absorbing these substan- rom animal matter, that they effect its decomposi- for, when diluted with a sufficient quantity of r, or combined with any oily substance, they lose causticity.

But, to return to the general properties of alkalies—they change the colour of syrup of violets, and other blue vegetable infusions, to green; and have, in general, a very great tendency to unite with acids, although the respective qualities of these two classes of bodies form a remarkable contrast.

We shall examine the result of the combination of acids and alkalies more particularly when we have completed our general view of the simple bodies. It will be sufficient at present to inform you, that whenever acids are brought in contact with alkalies, or alkaline earths, they unite with a remarkable eagerness, and form compounds perfectly different from either of their constituents; these compounds are called *neutral* or *compound salts*.

Caroline. Are they of the same kind as the salts formed by the combination of a metal and an acid?

Mrs. B. Yes; they are analogous in their nature, although different in many of their properties.

A methodical nomenclature, similar to that of the acids, has been adopted for the compound salts. Each individual salt derives its name from its constituents, so that every name implies a knowledge of the composition of the salt.

The three alkalies, the alkaline earths, and the metals, are called *salifiable bases* or *radicals*, and the acids, *salifying principles*. The name of each salt is composed both of that of the acid and the salifiable base; and it terminates in *at* or *it*, according to the degree of oxygenation of the acid. Thus, for instance, all those salts which are formed by the combination of the sulphuric acid with any of the salifiable bases, are called *sulphats*, and the name of the radical is added for the specific distinction of the salt; if it be potash, it will compose a *sulphat of potash*; if ammonia, *sulphat of ammonia*, &c.

Emily. The chrystals which we obtained from the combination of iron and sulphuric acid, were therefore *sulphat of iron*?

Mrs. B. Precisely; and those which we prepared by dissolving copper in nitric acid, *nitrat of copper*, and

Mrs. B. Take care, however, not to introduce the ·rd oxydate instead of rust, in general conversation; either you will not be understood, or you will be ·ghed at for your conceit.

Caroline. I confess that my attention is, at present ·much engaged by chemistry, that it sometimes leads into ridiculous observations. Every thing in nature ·efer to chemistry, and have often been laughed at ·my continual allusions to it.

Mrs. B. You must be more cautious and discreet ·this respect, my dear, otherwise your enthusiasm, ·ough proceeding from a sincere admiration of the ·ence, will be attributed to pedantry.

Metals differ very much in their affinity for each oth- ; some will not unite at all, others readily combine ·ether, and on this property of metals the art of *sold-·ng* depends.

Emily. What is soldering?

Mrs. B. It is joining two pieces of metal together, ·beating them, with a thin plate of a more fusible me- interposed between them. Thus tin is a solder for ·d; brass, gold, or silver, are solder for iron, &c.

Caroline. And is not *plating* metals something of the ·ne nature?

Mrs. B. In the operation of plating, two metals are ·ited, one being covered with the other, but without · intervention of a third; iron or tin may thus be cov- ·d with gold or silver.

Emily. Mercury appears to me of a very different ·ure from the other metals.

Mrs. B. One of its greatest peculiarities is that it ·ains a fluid state at the temperature of the atmos- ·ere. All metals are fusible at different degrees of ·at, and they have likewise each the property of free- ·g or becoming solid at a certain fixed temperature. ·ercury congeals only at 72° below the freezing point.

Emily. That is to say, that in order to freeze, it re- ·ires a temperature 72° colder than that at which wa- · freezes.

Mrs. B. Exactly so.

Caroline. But is the temperature of the atmosphere ever so low as that?

Mrs. B. Scarcely ever, at least in any inhabited part of the globe; therefore mercury is never found solid in nature, but it may be congealed by artificial cold; I mean such intense cold as can be produced by some chemical mixtures.

Caroline. And can mercury be made to boil and evaporate?

Mrs. B. Yes, like any other liquid; only it requires a much greater degree of heat. At the temperature of 600.o, it begins to boil and evaporate like water.

Mercury combines with gold, silver, tin, and with several other metals; and, if mixed with any of them in a sufficient proportion, it penetrates the solid metal, softens it, loses it own fluidity, and forms an amalgam, which is the name given to the combination of any metal with mercury, forming a substance more or less solid, according as the mercury or the other metal predominates.

Emily. In the list of metals there are some whose names I have never before heard mentioned.

Mrs. B. There are several that have been recently discovered, whose properties are yet but little known, as for instance, titanium which was discovered by the Revd. Mr. Gregor, in the tin mines of Cornwall; columbium, which has lately been discovered by Mr. Hatchett; and osmium, iridium, palladium, and rhodium, all of which Dr. Woolaston and Mr. Tennant found mixed with crude platina.

Caroline. Arsenic has been mentioned amongst the metals; I had no notion that it belonged to that class of bodies, for I had never seen it but as a powder, and never thought of it but as a most deadly poison.

Mrs. B. In its pure metallic state, I believe, it is not so poisonous; but it has so great an affinity for oxygen, that it absorbs it from the atmosphere at its natural temperature; you have seen it therefore, only in its state of oxyd, when, from its combination with oxygen it has acquired its very poisonous properties.

. But this is not all ; if the salt be formed by that of acids which ends in *ous* (which you know, in-es a less degree of oxygenation), the termination e name of the salt will be in *it*, as *sulphit of pot-sulphit of ammonia*, &c.

ily. There must be an immense number of com-d salts, since there is so great a variety of salifia-adicals, as well as of salifying principles.

rs. B. Their real number cannot be ascertained, it increases every day as the science advances. before we proceed farther in the investigation of ompound salts, it is necessary that we should ex-e the nature of the ingredients from which they omposed. Let us therefore return to the alkalies. dry white powder which you see in this phial is caustic POTASH ; it is very difficult to preserve it in tate, as it attracts with extreme avidity the mois-from the atmosphere, and if the air were not per-excluded, it would in a very short time be actually ed.

nily. It is then, I suppose, always found in a li-state ?

rs. B. No ; it exists in nature in a great variety rms and combinations, but is never found in its separate state ; it is combined with carbonic acid, which it exists in every part of the vegetable king-, and is most commonly obtained from the ashes egetables, which compose the substance that re-s after all the other parts have been volatilized by bustion.

roline. But you once said, that after the volatile of a vegetable were evaporated, the substance remained was charcoal ?

rs. B. What, my dear ? Do you still confound the esses of simple volatilization and combustion ? In r to procure charcoal we evaporate such parts as be reduced to vapour by heat alone ; but when we the vegetable, we volatilize the carbone also, by erting it into carbonic acid gas.

roline. That is true ; I hope I shall make no more akes in my favourity theory of combustion.

since they are vegetable ashes?

Mrs. B. They always contain more or le
but are very far from consisting of that substa
as they are a mixture of various earths and s
remain after the combustion of vegetables,
which it is not easy to separate the alkali i
form. The process by which potash is obta
in the imperfect state in which it is used in t
much more complicated than simple comb
was once deemed impossible to separate it en
all foreign substances, and it is only in chemi
tories that it is to be met with in the state c
which you find it in this phial. Wood ashes
ever, valuable for the alkali which they co
are used for some purposes without any furth
ation. Purified in a certain degree, they ma
commonly called *pearl ash*, which is of great
taking out grease, in washing linen, &c.
combines readily with oil or fat, with whic
a compound well known to you under the na

Caroline. Really! Then I should think i
better to wash all linen with pearl ash than
as, in the latter case, the alkali, being al
bined with oil, must be less efficacious in
grease.

and animal fibre, in virtue of its attraction for r and oil, and converts all animal matter into a kind ponaceous jelly.

nily. Are vegetables the only source from which h can be derived?

rs. B. No: for though far most abundant in vegeles, it is by no means confined to that class of bo- being found also on the surface of the earth mixed various minerals, especially with earths and stones, ce it is supposed to be conveyed into vegetables e roots of the plant. It is also met with, though ry small quantities, in some animal substances. most common state of potash is that of *carbonat;* I ose you understand what that is?

nily. I believe so; though I do not recollect that ever mentioned the word before. If I am not mis- , it must be a compound salt formed by the union rbonic acid with potash.

rs. B. Very true; you see how admirably the enclature of modern chemistry is adapted to assist nemory; when you hear the name of a compound, necessarily learn what are its constituents; and you are acquainted with the constituents, you can ediately name the compound that they form.

roline. Pray, how were bodies arranged and dis- ished before this nomenclature was introduced?

rs. B. Chemistry was then a much more difficult ; for every substance has an arbitrary name, h it derived either from the person who discover- as *Glauber's salts* for instance, or from some oth- cumstance relative to it, though quite unconnect- th its real nature, as *potash.*

ese names have been retained for some of the sim- odies; for as this class is not numerous, and there- can easily be remembered, it has not been thought ssary to change them.

mily. Yet I think it would have rendered the new enclature more complete to have methodized the es of the elementary as well as of the compound s, though it could not have been done in the same ner. But the names of the simple substances might

introducing into science an entire set of new obliges all the teachers and professors to g again; and if some of the old names, that a ceptionable, were not left as an introduction ones, few people would have had industry an rance enough to submit to the study of a comp language; and the inferior classes of artist only act from habit and routine, would, at time, have felt material inconvenience fr change of their habitual terms. From thes ations, Lavoisier and his colleagues, who i new nomenclature, thought it most pruden few links of the old chain, in order to con the new one. Besides, you may easily c inconvenience which might arise from givin nomenclature to substances, the simple natu is always uncertain; for the new names haps, have proved to have been founded in e indeed, cautious as the inventors of the mo cal language have been, it has already bee cessary to modify it in many respects. In t ses, however, in which new names have b to designate simple bodies, the names ha contrived as to indicate one of the chief p the body in question; this is the case w

engaged when fluids become solid, and cold pro-
l when solids are melted ?

rs. B. The latter is really the case in all solu-
; and if the solution of caustic alkalies seems to
: an exception to the rule, it does not, I believe,
any solid objection to the theory. The matter
be explained thus : When water first comes in
ct with the potash, it produces an effect similar to
lakeing of lime, that is, the water is solidified in
ining with the potash, and thus loses its latent
; this is the heat that you now feel, and which is,
fore, produced not by the melting of the solid,
by the solidification of the fluid. But when there
re water than the potash can absorb and solidify,
tter then yields to the solvent power of the water ;
f we do not perceive the cold produced by its melt-
it is because it is counterbalanced by the heat pre-
ly disengaged.* [*See Note page* 164.]

very remarkable property of potash is the forma-
of glass by its fusion with silicious earth. You
ot yet acquainted with this last substance further
its being in the list of simple bodies. It is suffi-
t, for the present, that you should know that sand
flint are chiefly composed of it ; alone it is infusi-
but mixed with potash, it melts when exposed to
eat of a furnace, combines with the alkali, and
into glass.

roline. Who would ever have supposed that the
substance that converts transparent oil into such
paque body as soap, should transform that opaque
tance, sand, into transparent glass !

rs. B. The transparency, or opacity of bodies,
not, I conceive, depend so much upon their inti-
nature, as upon the arrangement of their parti-
; we cannot have a more striking instance of this,
that which is afforded by the different states of
one, which, though it commonly appears in the
of a black opaque body, sometimes assumes the
dazzling transparent form in nature, that of dia-
d, which, you recollect, is nothing but carbone,
which, in all probability, derives its beautiful trans-

P

parency from the peculiar arrangement of its parti
during their crystallization.

Emily. I never should have supposed that the f
mation of glass was so simple a process as you desc
it.

Mrs. B. It is by no means an easy operati
make perfect glass; for if the sand, or flint, from w
the silicious earth is obtained be mixed with any m
lic particles, or other substance which cannot be
fied, the glass will be discoloured, or defaced by o
specks.

Caroline. That I suppose is the reason why c
so often appear irregular and shapeless through t
mon glass window.

Mrs. B. This species of imperfection proc
believe, from another cause. It is extremely
to prevent the lower part of the vessels in wh
materials of glass are fused, from containing
dense vitreous matter than the upper, on account
heavier ingredients falling to the bottom. Wh
happens, it occasions the appearance of veins c
in the glass, from the difference of density in
ral parts, which produces an irregular refractio
rays of light that pass through it.

Another species of imperfection sometime
from the fusion not being continued for a length
sufficient to combine the two ingredients com
or from the due proportion of potash and silex
are as two to one), not being carefully observ
glass, in those cases, will be liable to alterati
the action of the air, of salts, and especially c
which will effect its decomposition by combini
the potash and forming compound salts.

Emily. What an extremely useful substan
ash is!

Mrs. B. Besides the great importance of p
the manufactures of glass and soap, it is of ve
siderable utility in many of the other arts, an
combinations with several acids, particularly th
with which it forms saltpetre.

ne. Then saltpetre must be a *nitrat of potash ?*
are not yet acquainted with the nitric acid ?

B. We shall, therefore, defer entering into
iculars of these combinations, till we come to a
review of the compound salts. In order to
onfusion, it will be better at present to confine
es to the alkalies.

y. Cannot you shew us the change of colour
ou said the alkalies produced on blue vegetable
s ?

B. Yes ; very easily. I shall dip a piece of
aper into this syrup of violets, which, you see,
leep blue, and dyes the paper of the same co-
As soon as it is dry, we shall dip it into a solu-
potash, which, though itself colourless, will
paper green—

ine. So it has indeed ! And do the other alka-
duce a similar effect ?

B. Exactly the same.—We may now proceed
, which, however mportant, will detain us but
hort time ; as in all its general properties it
rongly resembles potash ; indeed, so great is
nilitude, that they have been long confounded,
y can now scarcely be distinguished except by
rence of the salts which they form with acids.
great source of this alkali is the sea, where,
d with a peculiar acid, it forms the salt with
ie waters of the ocean are so strongly impreg-

y. Is not that the common table salt ?

B. The very same ; but again we must post-
ntering into the particulars of this interesting
ition, till we treat of the neutral salts. Soda
obtained from common salt ; but the easiest
st usual method of procuring it, is by the com-
of marine plants, an operation perfectly analo-
that by which potash is obtained from vegeta-

. From what does soda derive its name ?

B. From a plant called by us *soda*, and by the

Arabs *kali;* which affords it in great abundance. Kali has, indeed, given its name to the alkalies in general.

Caroline. Does soda form glass and soap, in the same manner as potash?

Mrs. B. Yes; it does; it is of equal importance in the arts, and it is even prefered to potash for some purposes; but you will not be able to distinguish their properties, till we examine the compound salts which they form with acids; we must therefore leave soda for the present, and proceed to AMMONIA, or the VOLATILE ALKALI.

Emily. I long to hear something of this alkali; is it not of the same nature as hartshorn?

Mrs. B. Yes, it is, as you will see by and by. This alkakli is seldom found in nature in its pure state; it is most commonly extracted from a compound salt called *sal ammoniac*, which was formerly imported from *Ammonia*, a region of Lybia, from which both the salt and the alkali, derive their names. The crystals contained in this bottle are specimens of this salt, which consists of a combination of ammonia and muriatic acid.

Caroline. Then it should be called *muriat of ammonia;* for though I am ignorant what muriatic acid is, yet I know that its combination with ammonia cannot but be so called; and I am surprised to see sal ammoniac inscribed on the label.

Mrs. B. That is the name by which it has been so long known, that the modern chemists have not yet succeeded in banishing it altogether; and it is still sold under that name by druggists, though by scientific chemists it is more properly called muriat of ammonia.

Emily. By what means can the ammonia be separated from the muriatic acid?

Mrs B. By a display of chemical attractions; but this operation is too complicated for you to understand, till you are better acquainted with the agency of affinities.

Emily. And when extracted from the salt, what kind of substance is ammonia?

Mrs. B. Its natural form at the temperature of the atmosphere, when free from combination, is that of

gas; and in this state it is called *ammoniacal gas*. But it mixes very readily with water, and can be thus obtained in a liquid form.

Caroline. You said that ammonia was a compound; pray, of what principles is it composed?

Mrs. B. It was discovered a few years since, by Berthollet, a celebrated French chemist, that it consisted of about one part of hydrogen to four parts of nitrogen. Having heated ammoniacal gas under a receiver, by causing the electrical spark to pass repeatedly thro' it, he found that it increased considerably in bulk, lost all its alkaline properties, and was actually converted into hydrogen and nitrogen gasses.

Emily. Ammoniacal gas must, I suppose, be very heavy, since it expands so much when decomposed?

Mrs. B. Compared with hydrogen gas, it certainly is; but it is considerably lighter than oxygen gas, and only about half the weight of atmospherical air. It possesses most of the properties of the fixed alkalies; but cannot be of so much use in the arts on account of its volatile nature. It is, therefore, never employed in the manufacture of glass, but it forms soap with oils equally as well as potash and soda; it resembles them likewise in its strong attraction for water; for which reason it can be collected in a receiver over mercury only.

Caroline. I do not understand this?

Mrs. B. Do you recollect the method which we used to collect gasses in a glass receiver over water?

Caroline. Perfectly.

Mrs. B. Ammoniacal gas has so strong a tendency to unite with water, that, instead of passing through that fluid, it would be instantaneously absorbed by it. We can therefore neither use water for that purpose, nor any other liquid of which water is a component part; so that, in order to collect this gas, we are obliged to have recourse to mercury (a liquid which has no action upon it), and we use a mercurial bath, instead of a water bath, as we did on former occasions. Water impregnated with this gas, is nothing more than the fluid which you mentioned at the beginning of the con-

versation—hartshorn; it is the ammoniacal gas escaping from the water which gives it so powerful a smell.

Emily. But there is no appearance of effervescence in hartshorn?

Mrs. B. Because the particles of gas that rise from the water are too subtle and minute for their effect to be visible.

Water diminishes in density by being impregnated with ammoniacal gas; and this augmentation of bulk increases its capacity for caloric.

Emily. In making hartshorn, then, or impregnating water with ammonia, heat must be absorbed, and cold produced?

Mrs. B. That effect would take place if it was not counteracted by another circumstance; the gas is liquefied by incorporating with the water, and gives out its latent heat. The condensation of the gas more than counterbalances the expansion of the water; therefore, upon the whole, heat is produced.—But if you dissolve ammoniacal gas with ice or snow, cold is produced.—Can you account for that?

Emily. The gas, in being condensed into a liquid, must give out heat; and, on the other hand, the snow or ice, in being rarefied into a liquid must absorb heat; so that, between the opposite effects, I should have supposed the original temperature would have been preserved.

Mrs. B. But you have forgotten to take into the account the rarefaction of the water (or melted ice) by the impregnation of the gas; and this is the cause of the cold which is ultimately produced.

Caroline. Is the *sal volatile* (the smell of which so strongly resembles hartshorn) likewise a preparation of ammonia?

Mrs. B. It is carbonat of ammonia dissolved in water; and which, in its concrete state, is commonly called salts of harthorn. Ammonia is caustic like the fixed alkalies, as you may judge by the pungent effects of hartshorn, which cannot be taken internally or applied to delicate external parts, without being plentiful-

ly diluted with water—Oil and acids are very excellent antidotes for alkaline poisons; can you guess why?

Caroline. Perhaps, because the oil combines with the alkali, and forms soap, and thus destroys its caustic properties; and the acid converts it into a compound salt, which I suppose, is not so pernicious as caustic alkali.

Mrs. B. Precisely so.

Ammoniacal gas, if it be mixed with atmospherical air, and a burning taper repeatedly plunged into it, will burn with a large flame of a peculiar yellow colour.

Emily. I thought that all the alkalies were incombustible?

Caroline. Besides, you say that flame is produced by the combustion of hydrogen only?

Mrs. B. And is not hydrogen gas one of the constituents of ammoniacal gas? Therefore, though generally speaking, the alkalies are incombustible, yet one of the constituents of ammonia is eminently combustible.

Emily. I own I had forgotten that ammonia was a compound. But pray tell me, can ammonia be procured from this Lybian salt only?

Mrs. B. So far from it, that it is contained in, and may be extracted from, all animal substances whatever. Hydrogen and nitrogen are two of the chief constituents of animal matter; it is therefore not surprising that they should occasionally meet and combine in those proportions that compose ammonia. But this alkali is more frequently generated by the spontaneous decomposition of animal substances; the hydrogen and nitrogen gasses that arise from putrified bodies combine, and form the volatile alkali.

Muriat of ammonia, instead of being exclusively brought from Lybia, as it originally was, is now chiefly prepared in Europe, by chemical processes. Ammonia, although principally extracted from this salt, can only be produced by a great variety of other substances. The horns of cattle, especially those of the dear, yield it in abundance, and it is from this circumstance that a solution of ammonia in water has been

called hartshorn. It may likewise be procured from wool, flesh and bones; in a word, any animal substance whatever yields it by decomposition.

We shall now lay aside the alkalies, however important the subject may be, till we treat of their combination with acids. The next time we meet we shall examine the earths, which will complete our review of the class of simple bodies, after which we shall proceed to their several combinations.

* If, however, this defence of the general theory be true, it ought to be found, on accurate examination, that a certain quantity of heat ultimately disappears: or should this explanation be rejected, the phenomenon may be accounted for by supposing that a solution of alkali in water has less capacity for heat than either water or alkali in their separate state.

Conversation XI.

On Earths.

Mrs. B.

THE earths, which we are to-day to examine ar[e]
in number:

SILEX,	STRONTITES,
ALUMINE,	YTTRIA,
BARYTES,	GLUCINA,
LIME,	ZIRCONIA,
MAGNESIA,	GARGONIA.

The five last are of very late discovery; thei[r pro]perties are but imperfectly known; and as they [have] not yet been applied to use, it will be unnecess[ary to] enter into any particulars respecting them; we [shall] confine our remarks, therefore, to the six first. [The] earths in general are, like the alkalies, incomb[ustible] substances.

Caroline. Yet I have seen turf burnt in the co[untry,] and it makes an excellent fire; the earth becom[es red] hot, and produces a very great quantity of heat.

Mrs. B. It is not the earth that burns my de[ar, but] the roots, grass, and other remnants of vegetabl[e]

rmixed with it. The caloric, which is produ-
the combustion of these substances, makes the
d hot, and this being a bad conductor of heat,
its caloric a long time ; but were you to examine
cooled, you would find that it had not absorbed
ticle of oxygen, nor suffered any alteration from
. Earth is, however, from the circumstance
ntioned, an excellent reflector of heat, and owes
y when mixed with fuel, solely to that property.
this point of view that Count Rumford has re-
nded balls of incombustible substances to be ar-
in fire places, and mixed with the coals, by
neans the caloric disengaged by the combustion
tter, is more perfectly reflected into the room,
expense of fuel is saved.

, you know, was supposed to be one of the
ments ; but now that a variety of earths have
scovered and clearly discrimated, no single one
exclusively called an element ; and as none of
ve been decomposed, they have an equal title
nk of simple bodies, which are the only ele-
hat we now acknowledge. It is from these
either in their simple state, or mixed together
bined with other minerals, that the solid part
globe is formed.

. When I think of the great variety of soils, I
nished that there are not a great number of earths
them.

B. You might, indeed, almost confine that
to four ; for barytes, strontites, and the others
liscovery, act but so small a part in this great
that they cannot be reckoned as essential to the
formation of the globe. And you must not
your idea of earths to the formation of soil ; for
arble, chalk, slate, sand, flint, and all kinds of
from the precious jewels to the commonest peb-
a word all the immense variety of mineral pro-
nay be referred to some of these earths, either
ple state, or combined the one with the other,
ed with other ingredients.

ine. Precious stones composed of earth ! That
ery difficult to conceive.

Emily. Is it more extraordinary than that the most precious of all jewels, diamond, should be composed of carbone? But diamond forms an exception, Mrs. B—; for, though a stone, it is not composed of earth.

Mrs. B. I did not specify the exception, as I knew you were so well acquainted with it. Besides, I would call diamond a mineral rather than a stone, as the latter term always implies the presence of some earth.

Caroline. I cannot conceive how such coarse materials can be converted into such beautiful productions.

Mrs. B. We are very far from understanding all the secret resources of nature; but I do not think the spontaneous formation of the crystals, which we call precious stones, one of the most difficult phenomena to comprehend.

By the slow and regular work of ages, perhaps of hundreds of ages, these earths may be gradually dissolved by water, and as gradually deposited by their solvent in the slow and undisturbed process of crystallization. The regular arrangement of their particles during their reunion in a solid mass, gives them the brilliancy, transparency, and beauty, for which they are so much admired: and renders them in appearance so totally different from their rude and primitive ingredients.

Caroline. But how does it happen that they are spontaneously dissolved, and afterwards crystallized?

Mrs. B. The scarcity of many kinds of crystals, as rubies, emeralds, topazes, &c. shows that their formation is not an operation very easily carried on in nature. But cannot you imagine that when water, holding in solution some particles of earth, filters through the crevices of hills or mountains, and at length dribbles into some cavern, each successive drop may be slowly evaporated, leaving behind it the particle of earth which it held in solution? You know that crystallization is more regular and perfect, in proportion as the evaporation of the solvent is slow and uniform; Nature, therefore, who knows no limit of time, has, in all works of this kind, an infinite advantage over any artist who attempts to imitate such productions.

mily. I can now conceive that the arrangement of particles of earth, during crystallization, may be as to occasion transparency, by admitting a free age to the rays of light; but I cannot understand crystallized earths should assume such beautiful ırs as most of them do. Sapphire, for instance, a celestial blue; ruby, a deep red; topaz, a bril- yellow?

rs. B. Nothing is more simple than to suppose the arrangement of their particles is such, as to mit some of the coloured rays of light, and to re- others, in which case the stone must appear of olour of the rays which it reflects. But, besides, quently happens, that the colour of a stone is ow- o a mixture of some metallic matter.

roline. Pray, are the different kinds of precious s each composed of one individual earth, or are formed of a combination of several earths?

rs. B. A great variety of materials enters into composition of most of them; not only several s, but sometimes salts and metals. The earths, ver, in their simple state, frequently form very tiful crystals; and, indeed, it is in that state only they can be obtained perfectly pure.

nily. Is not the Derbyshire spar produced by the allization of earths, in the way you have just ex- ed? I have been in some of the subterraneous cav- where it is found, which are such as you have des- d.

rs. B. Yes; but this spar is a very imperfect nen of crystallization; it consists of a great vari- f ingredients confusedly blended together, as you judge by its opacity, and by the various colours ppearances which it exhibits.

t, in examining the earths in their most perfect greeable form, we must not lose sight of that in which they are most commonly found, and ı, if less pleasing to the eye, is far more interest- y its utility. Before we proceed further, however, uld observe, that although the earths are consid- as simple substances (as chemists have not suc- ed in decomposing them) yet there is considerable

Mrs. B. Not if their attraction for it. I
that they will yield it to no other substance
ing its state of combination, the properties
may be so altered, as to be concealed er
our observation; and it is possible that this
case with the earths. Let us suppose th
stance, to have been originally some pecu
whose affinity for oxygen was so great, th
tracted it from every substance, and c
would yield it to none; such metals must
the state of oxyds; and, as we should not
them under their metalic form, we could
them as metals, but should distinguish th
specific name, as we have done with re
earths.

Caroline. That, indeed, seems very pr
metals, when oxydated, become to all a
kind of earthy substance.

Emily. But have the earths any of th
of the metallic oxyds?

Mrs. B. Their strongest feature of res
their property of combining with the acids t
pound salts.

You must not, however, consider the id

are called *alkaline earths*, because they possess those qualities in so great a degree, as to entitle them, in most respects, to the rank of alkalies. They combine and form compound salts with acids in the same way as alkalies; they are, like them, susceptible of a considerable degree of causticity and are similarly acted upon by chemical tests.—The other earths, silex and alumine, with one or two others of late discovery, are in some degree more earthy, that is to say, they possess more completely the properties common to all the earths, which are, insipidity, dryness, unalterableness in the fire, infusibility, &c.

Caroline. Yet, did you not tell us that silex, or silicious earths, when mixed with an alkali, was fusible, and ran into glass?

Mrs. B. Yes, my dear; but the characteristic properties of earths, which I have mentioned, are to be considered as belonging to them in a state of purity only; a state in which they are very seldom to be met with in nature.—Besides these general properties, each earth has its own specific characters, by which it is distinguished from any other substance. Let us therefore review them separately.

SILEX, or SILICA, abounds in flint, sand, sandstone, agate, jasper, &c.; it forms the basis of many precious stones, and particularly of those that strike fire with steel. It is rough to the touch, scratches and wears away metal; it is acted upon by no acid but the fluoric, and is not soluble in water by any known process; but nature certainly dissolves it by means with which we are unacquainted, and thus produces a variety of silicious crystals, and amongst these *rock crystal*, which is the purest specimen of this earth. Silex appears to have been intended by Providence to form the solid basis of the globe, to serve as a foundation for the original mountains, and give them that hardness and durability which has enabled them to resist the various revolutions which the surface of the earth has successively undergone. From these mountains silicious rocks have, during the course of ages, been gradually detached by torrents of water, and brought down in fragments; these, in the violence and rapidity of their des-

cent, are sometimes crumbled to sand, and in this state form the beds of rivers and of the sea, chiefly composed of silicious materials. Sometimes the fragments are broken without being pulverized by their fall, and assume the form of pebbles, which gradually become rounded and polished.

Emily. Pray what is the true colour of silex, which forms such a variety of different coloured substances? Sand is brown, flint is nearly black, and precious stones are of all colours?

Mrs. B. Pure silex, such as is found only in the chemist's laboratory, is perfectly white, and the various colours which it assumes, in the different substances you have just mentioned, proceed from the different ingredients with which it is mixed in them.

Caroline. I wonder that silex is not more valuable, since it forms the basis of so many precious stones.

Mrs. B. You must not forget that the value we set upon precious stones, depends in a great measure on the scarcity with which nature affords them; for, were those productions either common, or perfectly imitable by art, they would no longer, notwithstanding their beauty, be so highly esteemed. But the real value of silicious earth, in many of the most useful arts, is very extensive. Mixed with clay, it forms the basis of all the various kinds of earthen ware, from the most common utensils to the most refined ornaments.

Emily. And we must not forget its importance in the formation of glass with potash.

Mrs. B. Nor should we omit to mention, likewise, many other important uses of silex, such as being the chief ingredient of some of the most durable cements, of mortars, &c.

I said before, that silicious earth combined with no acid but the fluoric: it is for this reason that glass is liable to be attacked by that acid only, which, from its strong affinity for silex, forces that substance from its combination with the potash, and thus destroys the glass.

We will now hasten to proceed to the other earths, for I am rather apprehensive of your growing weary of this part of our subject.

Caroline. The history of earths is not quite so entertaining as that of the other simple substances.

Mrs. B. Perhaps not; but it is absolutely indispensable that you should know something of them; for they form the basis of so many interesting and important compounds, that their total omission would throw great obscurity on our general outline of chemical science. We shall, however, review them in as cursory a manner as the subject will admit of.

ALUMINE derives its name from a compound salt called *alum*, of which it forms the basis.

Caroline. But it ought to be just the contrary, Mrs. B. The simple body should give, instead of taking its name from the compound.

Mrs. B. Very true, my dear; but as the compound salt was known long before its basis was discovered, it was natural enough when that earth was at length separated from the acid, that it should derive its name from the compound from which it was obtained. However, to remove your scruples, we will call the salt according to the new nomenclature, *sulphat of Alumine.* From this combination, alumine may be obtained in its pure state; it is then soft to the touch, makes a paste with water, and hardens in the fire. In nature, it is found chiefly in clay, which contains a considerable proportion of this earth; it is very abundant in fuller's earth, slate, and a variety of other mineral productions.

There is indeed scarcely any mineral substance more useful to mankind than alumine. In the state of clay, it forms large strata of the earth, gives consistency to the soil of vallies, and of all low and damp spots, such as swamps and marshes. The beds of lakes, ponds, and springs, are almost entirely of clay; instead of allowing of the filtration of water, as sand does, it forms an impenetrable bottom, and by this means water is accumulated in the caverns of the earth, producing those reservoirs whence springs issue, and spout out at the surface.

Emily. I always thought that these subterraneous reservoirs of water were bedded by some hard stone, or rock, which the water could not penetrate.

Mrs. B. That is not the case; for in the course of

which do not retain a sufficient quantity
purpose of vegetation.

Alumine is the most essential ingred
ries. It enters into the composition o
as that of the finest china; the additi
water hardens it, renders it susceptible
vitrification, and makes it perfectly fit
purposes.

Caroline. I can scarcely conceive
china should be made of the same mat

Mrs. B. Brick consists almost en
clay; but a certain proportion of silex
the formation of earthen or stone wa
potteries sand is used for that purpose
silex is, I believe necessary for the co
celain, as well as a finer kind of clay;
rials are, no doubt, more carefully pre
ously wrought, in the one case than in
celain owes its beautiful semi-transpar
mencement of vitrification.

Emily. But the commonest earthe
not transparent, is covered with a kind

Mrs. B. That precaution is equal
use as for beauty, as the ware would be
ed and corroded by a variety of substa

Mrs. B. They are all composed of metallic oxyds, that these colours, instead of receiving injury from application of fire, are strengthened and developed its action, which causes them to undergo different rees of oxydation.

lumine and silex are not only often combined by but they have in nature a very strong tendency to e, and are found combined, in different proportions, arious gems and other minerals. Indeed, many of precious stones, such as ruby, oriental sapphire, thyst, &c. consist chiefly of Alumine.

Ve may now proceed to the alkaline earths. I shall but a few words on Barytes, as it is hardly ever l, except in chemical laboratories. It is remarkafor its great weight, and its strong alkaline proper- such as destroying animal substances, turning en some blue vegetable colours, and shewing a powl attraction for acids; this last property it possesses uch a degree, particularly with regard to the sulric acid, that it will always detect its presence in any tance or combination whatever, by immediately ing with it and forming a sulphat of barytes. This lers it a very valuable chemical test. It is found ty abundantly in nature in the state of carbonat, which the pure earth can be easily separated.

he next earth we have to consider is Lime.—This substance of too great and general importance to assed over so slightly as the last.

ime is strongly alkaline. In nature it is not met in its simple state, as its affinity for water and carc acid is so great, that it is always found combined these substances, with which it forms the common -stone; but it is separated in the kiln from these edients, which are volatilized whenever a sufficient ee of heat is applied.

mily. Pure lime then is nothing but lime-stone, h has been deprived in the kiln, of its water, and onic acid?

rs. B. Precisely; in this state it is called *quick-* and is so caustic, that it is capable of decomposthe dead bodies of animals very rapidly, without undergoing the process of putrefaction.—I have

excessively hot !—It swells, and now it bu
bles to powder, while the water on the l
pears to produce no kind of alteration.

Mrs. B. Because the lime-stone is al
ed with water, whilst the quick-lime, w
deprived of it in the kiln, combines wit
great avidity, and produces this prodigio
ment of heat, the cause of which I form
to you ; do you recollect it ?

Emily. Yes ; you said that the heat d
from the lime, but from the water which
and thus parted with its heat of liquidity.

Mrs. B. Very well. If we continue
sive quantities of water to the lime after
and crumbled as you see, it will then gr
fused in the water, till it will at length be
and entirely disappear ; but for this purpo
no less than 700 times its weight of wa
lution is called *lime-water.*

Caroline. How very small, then, is
of lime dissolved.

Mrs. B. Barytes is still of more diffi
it dissolves only in 900 times its weight
it is much more soluble in the state of c
liquid contained in this bottle is lime-wat

said that the attraction of lime for carbonic acid so strong, that it would absorb it from the atmos- e. We may see this effect by exposing a glass of -water to the air; the lime will then separate from water, combine with the carbonic acid, and re-ap- on the surface in the form of a white film, which bonat of lime, commonly called *chalk*.

roline. Chalk is, then, a compound salt? I never ld have supposed that those immense beds of chalk we see in many parts of the country, were a salt. , the white film begins to appear on the surface of water; but it is far from resembling hard solid .

rs. B. That is owing to its state of extreme di- n; in a little time it will collect into a more com- mass, and subside at the bottom of the glass.

you breathe into lime-water, the carbonic acid, h is mixed with the air that you expire, will pro- the same effect. It is an experiment easily made hall pour some lime-water into this glass tube, and, eathing repeatedly into it, you will soon perceive cipitation of chalk—

ily. I see already a small white cloud formed.

rs. B. It is composed of minute particles of ; at present it floats in the water, but it will soon de.

rbonat of lime, or chalk, you see, is insoluble in r, since the lime which was dissolved re-appears converted into chalk; but you must take notice very singular circumstance which is, that chalk is le in water impregnated with carbonic acid.

roline. It is very curious, indeed, that carbonic gas should render lime soluble in one instance, nsoluble in the other!

rs. B. I have here a little bottle of Seltzer water, h, you know, is strongly impregnated with car- acid—let us pour a little of it into a glass of lime r. You see that it immediately forms a precipit- of carbonat of lime!

mily. Yes, a white cloud appears.

Mrs. B. I shall now pour an additional quantity of Seltzer water into the lime water—

Emily. How singular! The cloud is re-diss and the liquid is again transparent.

Mrs. B. All the mystery depends upon this ci stance, that carbonat of lime is soluble in carboni whilst it is insoluble in water; the first quantity bonic acid, therefore, which I introduced in lime water, was employed in forming the carb lime, which remained visible, until an additiona tity of carbonic acid dissolved it. Thus, you see the lime and carbonic acid are in proper pro to form chalk, the white cloud appears, but w acid predominates, the chalk is no sooner form it is dissolved.

Caroline. That is now the case; but let us t ther a further addition of lime water will again itate the chalk.

Emily. It does, indeed! the cloud re-appe cause, I suppose, there is now no more of the ic acid than is necessary to form chalk; and, to dissolve the chalk, a superabundance of ac quired.

Mrs. B. We have, I think, carried this ment far enough; every repetition would but the same appearances.

Lime combines with most of the acids, to w carbonic (being the weakest) readily yields these combinations we shall have an opportuni ticing more particularly hereafter. It uni phosphorus, and with sulphur, in their simp in short, of all the earths, lime is that whic employs most frequently and most abundant innumerable combinations. It is the basis of reous earths and stones; we find it likewise in mal and the vegetable creations.

Emily. And in the arts is not lime of w utility?

Mrs. B. Scarcely any substance more know that it is a most essential requisite in as it constitutes the basis of all cements, such tars, stucco, plaster, &c.

Lime is also of infinite importance in agricu lightens and warms soils that are too cold, a

consequence of too great a proportion of clay. ould be endless to enumerate the various pur- r which it is employed; and you know enough form some idea of its importance: we shall, e, now proceed to the third alkaline earth, IA.

ne. I am already pretty well acquainted with h, it is a medicine.

B. It is in the state of carbonat that magnesia y employed medicinally; it then differs but appearance from its simple form, which is that fine light white powder. It dissolves in 2000 weight of water, but forms with acids ex- soluble salts. It has not so great an attrac- cids as lime, and consequently yields them to r. It is found in a great variety of mineral tions, such as slate, mica, amianthus, and more rly in a certain lime-stone, which has lately covered by Mr. Tennant to contain it in very antities. It does not attract and solidify water, ; but when mixed with water, and exposed mosphere, it slowly absorbs carbonic acid from r, and thus loses its causticity. Its chief use ine is, like that of lime, derived from its rea- combine with, and neutralize, the acid which with in the stomach.

. Yet, you said it was taken in the state of , in which case it is already combined with an

B. Yes; but the carbonic is the last of all the the order of affinities; it will therefore yield nesia to any of the others. It is, however, ly taken in its caustic state as a remedy for e. Combined with sulphuric acid, magnesia other and more powerful medicine, common- *Epsom salt.*

ne. And properly, *sulphat of magnesia*, I sup- ray why was it ever called Epsom salt?

s. B. Because there is a spring in the neigh- of Epsom, which contains this salt in great ce.

The last alkaline earth which we h
STRONTIAN, or STRONTITES, discove
a few years ago. It so strongly rese
its properties, and is so sparingly fou
of so little use in the arts, that it will
to enter into any particulars respectin
most remarkable characteristic prope
is, that its salts, when dissolved in spi
the flame of a deep red, or blood colo

We shall here conclude this lecture
meeting, you will be introduced to
different from any of the preceding.

Conversations

ON

CHEMISTRY.

VOLUME II.

ON COMPOUND BODIES.

Aug. Van Schaick

1810

[illegible]

Conversations

ON

CHEMISTRY.

ON COMPOUND BODIES.

Conversation XII.

ON THE ATTRACTION OF COMPOSITION.

Mrs. B.

AVING completed our examination of the simple
ementary bodies, we are now to proceed to those
compound nature; but before we enter on this ex-
ve subject, it will be necessary to make you ac-
ited with the principal laws by which chemical
inations are governed.

u recollect, I hope, what we have formerly said
e nature of the attraction of composition, or che-
l attraction, or affinity, as it is also called?

nily. Yes, I think perfectly; it is the attraction
ubsists between bodies of a different nature, which
ions them to combine and form a compound, when
come in contact.

rs. B. Very well; your definition comprehends
irst law of chemical attraction, which is, that *it
place only between bodies of a different nature;* as,
nstance, between an acid and an alkali; between
en and a metal, &c.

R

Caroline. That we understand of course; for the attraction between particles of a similar nature is that of aggregation, or cohesion, which is independent of any chemical power.

Mrs. B. The second law of chemical attraction is, that *it takes place only between the most minute particles of bodies;* therefore, the more you divide the particles of the bodies to be combined, the more readily they act upon each other.

Caroline. That is again a circumstance which we might have supposed; for the finer the particles of the two substances are, the more easily and perfectly they will come in contact with each other, which must greatly facilitate their union. It was for this purpose, you said, that you used iron filings in preference to wire or pieces of iron, for the decomposition of water.

Mrs. B. It was once supposed that no mechanical power could divide bodies into particles sufficiently minute for them to act upon each other; and that, in order to produce the extreme division requisite for a chemical action, one, if not both of the bodies, should be in a fluid state. There are, however, a few instances, in which two solid bodies very finely pulverized, exert a chemical action on one another; but such exceptions to the general rule are very rare indeed.

Emily. In all the combinations that we have hitherto seen, one of the constituents has, I believe, been either liquid or aeriform. In combustions, for instance, the oxygen is taken from the atmosphere, in which it existed in the state of gas; and whenever we have seen acids combine with metals or with alkalies, they were either in a liquid or an aeriform state.

Mrs. B. The third law of chemical attraction is, *that it can take place between two, three, four or even a greater number of bodies.*—Can you recollect any examples of these double, triple, and quadruple combinations?

Caroline. Oxyds and acids are bodies composed of two constituents; compound salts of three: but I recollect no instance of the combination of four principles, unless it be amongst the earths in the formation of stones.

Mrs. B. Such examples very frequently occur a- gst the earths; but you might have quoted, as in- ces of quadruple compounds, all those that result the combination of acids with ammonia, or vola- lkali.

roline. True. As ammonia is itself a compound, nion with the acids, which are also composed of principles, must form a quadruple combination.

rs. B. You will soon become acquainted with a variety of these complicated compounds. The law of chemical attraction is, that *a change of tem- ure always takes place at the moment of combination,* is occasioned by the change of capacity for heat, takes place in bodies, when passing from a sim- a combined state. Do you recollect any instance is, Emily?

ily. Yes; when lime, or any of the alkalies, or ne earths, combine with, and solidify water, the e of its heat of liquidity is set at liberty.

rs. B. I had rather that you had chosen any oth- stance, as the union of water with the alkalies and ne earths is not, strictly speaking, a chemical ination; for the water remains in the state of wa- no' condensed and solidified in the alkali; and can parated from it and restored to its fluid state, mere- the restitution of its heat of liquidity.

m going to show you a very striking instance of hange of temperature arising from the combina- of different bodies.—I shall pour some nitrous acid is small quantity of oil of turpentine—the oil will ntly combine with the oxygen of the acid, and pro- a considerable change of temperature.

roline. What a blaze! The temperature of the d the acid must be elevated, indeed, to produce a violent combustion.

rs. B. There is, however, a peculiarity in this ustion, which is, that the oxygen, instead of be- derived from the atmosphere alone, is principally lied by the acid itself.

nily. And are not all combustions instances of the

change of temperature produced by the chemical combination of two bodies?

Mrs. B. Undoubtedly; when oxygen loses its gaseous form in order to combine with a solid body, it becomes condensed, and the caloric evolved produces the elevation of temperature. The specific gravity of bodies is at the same time altered by chemical combination; for in consequence of a change of capacity for heat, a change of density must be produced.

Caroline. That was the case with the sulphuric acid and water, which by being mixed together, gave out a great deal of heat, and proportionally increased in density.

Mrs. B. I do not think the instance to which you refer is quite in point; for there does not appear to be what we have called a true chemical combination between sulphuric acid and water, since they are only mixed together, and undergo no other change than a loss of caloric, so that they may be separated again from each other merely by evaporating the water. Yet you have truly observed in this instance that the particles of the two fluids so far penetrate each other, as to form a more compact substance, in consequence of which a quantity of latent heat is forced out, and there is an increase of sphecific gravity.

The 5th law of chemical attraction is, that *the properties which characterise bodies when separate, are altered or destroyed by their combination.*

Caroline. Certainly; what, for instance, can be so different from water as the hydrogen and oxygen gasses?

Emily. Or what more unlike sulphat of iron, than iron or sulphuric acid?

Caroline. But of all metamorphoses, that of sand and potash into glass, is the most striking!

Mrs. B. Every chemical combination is an illustration of this rule. But let us proceed—

The 6th law is, that *the force of chemical affinity, between the constituents of a body, is estimated by that which is required for their separation.* This force is by no means proportional to the facility with which bodies unite; for

ıganese, for instance, which, you know, has so at an attraction for oxygen, that it is never found in ıetallic state, yields it more easily than any other :al.

Caroline. And likewise lime, which has a great at- :tion for carbonic acid, yields it to any of the other ls, and even to heat alone.

Emily. But, Mrs. B. you speak of estimating the ıe of attraction between bodies, by the force requir- to separate them ; how can you measure these for- ?

Mrs. B. They cannot be precisely *measured,* but y are comparatively ascertained by experiment, and be represented by numbers which express the ıtive degrees of attraction.

The 7th law is, that *bodies have amongst themselves* *erent degrees of attraction.* Upon this law (which ı may have discovered yourselves long since), the ɔle science of chemistry depends ; for it is by means he various degrees of affinity which bodies have each other, that all the chemical compositions and ɔmpositions are effected. Thus if you pour sul- ric acid on soap, it will combine with the alkali to exclusion of the oil, and form a sulphat of potash. ry chemical fact or experiment is an instance of the e kind ; and whenever the decomposition of a body erformed by the addition of any single new sub- ce, it is said to be effected by *simple elective attrac-*. But it often happens that no simple substance decompose a body, and, that, in order to effect this, must offer to the compound a body which is itself posed of two, or sometimes three principles, which ld not, each separately, perform the decomposition. his case there are two new compounds formed in sequence of a reciprocal decomposition and recom- ıtion. All instances of this kind are called *double elec-* *attractions.*

Caroline. I confess I do not understand this clearly.

Mrs. B. You will easily comprehend it by the as- ınce of this diagram, in which the reciprocal forces ıttraction are represented by numbers :

Original Compound.
Sulphat of Soda.

Soda 8 Sulphuric Acid.

Quiescent

Result Nitrat of Soda. 7 *Divellent* *Attractions* 6 } 13 *Result* Sulphat of Lime.

Attractions.

Nitric Acid 4 Lime

12

Original Compound.
Nitrat of Lime.

We here suppose that we are to decompose sul of soda ; that is, to separate the acid from the al if, for this purpose we add some lime, in order to it combine with the acid, we shall fail in our attemp cause the soda and the sulphuric acid attract each er by a force which is (by way of supposition) r sented by the number 8 ; while the lime tends to with this acid by an affinity equal only to the num It is plain, therefore, that the sulphat of soda w be decomposed, since a force equal to 8 cannot be come by a force equal only to 6.

Caroline. So far, this appears very clear.

Mrs. B. If, on the other hand, we endeavour compose this salt by nitric acid, which tends to bine with soda, we shall be equally unsuccessf nitric acid tends to unite with the alkali by a force only to 7.

In neither of these cases of simple elective a tion, therefore, can we accomplish our purpose. let us previously combine together the lime and acid, so as to form a nitrat of lime, a compoun

: constituents of which are united by a power equal 4. If then we present this compound to the sulphat soda, a decomposition will ensue, because the sum the forces which tend to preserve the two salts in ir actual state, is not equal to that of the forces which d to decompose them, and to form new combinations. e nitric acid, therefore, will combine with the soda, l the sulphuric acid with the lime.

Caroline. I understand you now very well. This able effect takes place because the numbers 8 and 4, ich represent the degrees of attraction of the con- uents of the two origal salts, make a sum less than numbers 7 and 6, which represent the degrees of traction of the two new compounds that will in conse- ence be formed.

Mrs. B. Precisely so.

Caroline. But what is the meaning of *quiescent* and *ellent* forces, which are written in the diagram ?

Mrs. B. Quiescent forces are those which tend to eserve compounds in a state of rest, or such as they tually are : divellent forces are those which tend to stroy that state of combination, and to form new com- unds.

These are the principal circumstances relative to the ctrine of chemical attractions, which have been laid wn as rules by modern chemists ; a few others might mentioned respecting the same theory, but of less portance, and such as would take us too far from our in. I should, however, not omit to mention that Mr. rthollet, a celebrated French chemist, has shewn, t whenever in chemical operations there is a display contrary attractions, the combinations which take ce depend not only upon the affinities, but also, in me degree, on the proportions of the substances con- rned.

Mrs. B.

Having now given you some idea of which chemical attractions are governed, v ceed to the examination of bodies that are consequence of these attractions.

The first class of compounds that presen to our notice, in our gradual ascent to th plicated combinations, are bodies composed principles. The sulphurets, phosphoret &c. are of this description; but the mo and important of these compounds are the of oxygen with the various simple sub which it has a tendency to unite. Of th already acquired some knowledge, and I h not be at a loss to tell me the general nan the combinations of oxygen with other su distinguished?

Emily. I believe you told us that all t tions of oxygen produced either oxyds or

Mrs. B. Very right; and with what s

ds, and likewise with their combinations with the alies, which form the triple compound called NEUAL SALTS.

You have, I believe, a clear idea of the nomenclae by which the base (or radical) of the acid, and the ious degrees of acidification, are expressed?

Emily. Yes, I think so; the acid is distinguished the name of its base, and its degree of acidity by the mination of that name in *ous* or *ic;* thus sulphur*ous* d is that formed by the smallest proportion of oxygen nbined with sulphur; sulphur*ic* acid is that which ults from the combination of sulphur with the greatquantity of oxygen.

Mrs. B. A still greater latitude may, in many cases, allowed to the proportions of oxygen than can be nbined with acidifiable radicals; for several of these licals are susceptible of uniting with a quantity of oxen so small as to be insufficient to give them the perties of acids; in these cases therefore, they are verted into oxyds. Such is sulphur, which by exsure to the atmosphere with a degree of heat inaduate to produce inflammation, absorbs a small protion of oxygen, which colours it red or brown. This erefore is the first degree of oxygenation of sulphur; 2d converts it into sulphur*ous* acid; the 3d into suluric acid; and, 4thly, if it was found capable of comning with a still larger proportion of oxygen, it would en be termed *super-oxygenated sulphuric acid.*

Emily. Are these various degrees of oxygenation mmon to all acids?

Mrs. B. No; they vary much in this respect; some susceptible of only one degree of oxygenation; ners, of two, or three; there are but very few that ll admit of more.

Caroline. The modern nomenclature must be of mense advantage in pointing out so easily the nature the acids, and their various degrees of oxygenation.

Mrs. B. Certainly. But great as are the advanges of the new nomenclature in this respect, it is not ssible to apply it in its full extent to all the acids, beuse the radicals or bases of some of them are still unown.

oxygen, that they will yield it to no oth
and in that case, you know, all the effo
mists are vain.

Emily. But if these acids have never
posed, should they not be classed with t
dies; for you have repeatedly told us th
bodies are rather such as chemists are un
pose, than such as are really supposed to
ly one principle?

Mrs. B. Analogy affords us so stro
the compound nature of the undecomp
that I never could reconcile myself to
with the simple bodies, though this div
adopted by several chemical writers,
the most strictly regular; but, as a sy
rangement is of use only to assist the mer
ing facts, we may, I think be allowed to
it when there is danger of producing con
lowing it too closely:—and this, I belie
the case, if you were taught to consider
pounded acids as elementary bodies.

Emily. I am sure you would not de

Caroline. We have heard of a great variety of acids; y how many are there in all?

Mrs. B. I believe there are reckoned at present ty-four, and their number is constantly increasing, the science improves; but the most important, and se to which we shall almost entirely confine our at-ion, are but few. I shall, however, give you a gen- view of the whole; and then we shall more partic-ly examine those that are the most essential.

This class of bodies was formerly divided into mine- vegetable, and animal acids, according to the sub-ces from which they were extracted.

Caroline. That I should think must have been an ellent arrangement; why was it altered!

Mrs. B. Because in many cases it produced con-on. In which class, for instance, would you place bonic acid?

Caroline. Now I see the difficulty. I should be at ss where to place it, as you have told us that it ex-in the animal, vegetable, and mineral kingdoms.

Emily. There would be the same objection with ect to phosphoric acid, which, though obtained efly from bones, can also, you said, be found in small ntities in stones, and likewise in some plants.

Mrs. B. You see, therefore, the propriety of chang- this mode of classification. These objections do exist in the present nomenclature; for the com-ition and nature of each individual acid is in some de- pointed out, instead of the class of bodies from ch it is extracted; and, with regard to the more eral division of acids, they are classed under these heads:

st. Acids of known and simple bases, which are ed by the union of these bases with oxygen.

hey are the following:

The *Sulphuric* *Carbonic* *Nitric* *Phosphoric* *Arsenical* *Tungstenic* *Molybdenic*	Acids of known and simple bases.

2dly. Those of unknown bases:

The *Muriatic* *Boracic* *Fluoric*	Acids of unknown base

These two classes comprehend the most an known and most important acids. The sulphu tric, and muriatic, were formerly, and are st quently, called *mineral acids*.

3dly. Acids that have double or binary radica which consequently consist of triple combinati These are the vegetable acids whose common is a compound of hydrogen and carbone.

Caroline. But if the basis of all the vegetabl be the same, it should form but one acid; it r deed combine with different proportions of oxyg the nature of the acid must be the same?

Mrs. B. The only difference that exists in ses of vegetable acids, is the various proportions drogen and carbone from which it is composed this is enough to produce a number of acids app very dissimilar. That they do not, however essentially, is proved by their susceptibility of converted into each other, by the addition or sub of a portion of hydrogen or of carbone.

The names of these acids are,

The *Acetic* *Oxalic* *Tartarous* *Citric* *Malic* *Gallic* *Mucous* *Benzoic* *Succinic* *Camphoric* *Suberic*	Acids of doubl being of v origin.

The 4th class of acids consists of those whi triple radicals, and are therefore of a still mo pound nature. This class comprehends the acids, which are:

[T]he *Lactic* *Prussic* *Formic* *Bombic* *Sebacic* *Zoonic* *Lithic*	Acids of triple bases, or animal acids.

: given this summary account or enumeration cids, as you may find it more satisfactory to once an outline, or general notion of the ex- e subject; but we shall now confine ourselves o first classes, which require our more imme- ention; and defer the remarks which we shall nake on the others, till we treat of the chemis- e animal and vegetable kingdoms.

acids of simple and known radicals are all ca- being decomposed by combustible bodies, to ey yield their oxygen. If, for instance, I pour f sulphuric acid on this piece of iron, it will a spot of rust; you know what that is ?

ne. Yes, it is an oxyd, formed by the oxygen id combining with the iron.

B. In this case you see the sulphur deposits gen by which it was acidified on the metal— in, if we pour some acid on a compound combus- stance, (we shall try it on this piece of wood) mbine with one or more of the constituents of stance, and occasion a decomposition.

. It has changed the colour of the wood to How is that?

B. The oxygen deposited by the acid has you know that wood in burning becomes black is reduced to ashes. Whether it derives the which burns it from the atmosphere, or from r source, the chemical effect on the wood is e. In the case of real combustion, wood be- lack because it is reduced to the state of char- he evaporation of its other constituents. But tell me the reason why wood turns black when the application of an acid ?

S

Caroline. First, tell me what are the ingredi
wood ?

Mrs. B. Hydrogen and carbone are the chie
stituents of wood, as of all other vegetable subst

Caroline. Well, then, I suppose that the oxy
the acid combines with the hydrogen of the wo
form water; and that the carbone of the woo
maining alone, appears of its usual black colour.

Mrs. B. Very well, indeed, my dear; that i
tainly the most plausible explanation.

Emily. Would not this be a good method of m
charcoal ?

Mrs. B. It would be an extremely expensiv
I believe, very imperfect method; for the act
the acid on the wood, and the heat produced by i
far from sufficient to deprive the wood of all its e
able parts.

Caroline. What is the reason that vinegar, l
and the acids of fruits, do not produce this ef
wood ?

Mrs. B. They are vegetable acids whose bas
composed of hydrogen and carbone; the oxygen,
fore, will not be disposed to quit this radical, wl
is already united with hydrogen. The stron
these may, perhaps, yield a little of their oxy
the wood, and produce a stain upon it; but the c
will not be sufficiently uncovered to assume its
colour. Indeed, the several mineral acids then
possess this power of charring wood in very di
degrees.

Emily. Cannot vegetable acids be decompo
any combustibles ?

Mrs. B. No; because their radical is comp
two substances which have a greater attraction f
gen than any known body.

Caroline. And are those strong acids whic
and decompose wood, capable of producing sim
fects on the skin and flesh of animals ?

Mrs. B. Yes; all the mineral acids, and
them more especially, possess powerful caustic
ties. They actually corrode and destroy the

sh : but they do not produce upon these exactly the me alteration as they do on wood, probably because ere is a great proportion of nitrogen and other sub-ances in animal matter, which prevents the separation carbone from being so conspicuous.

Conversation XIV.

the Sulphuric and Phosphoric Acids : or the combinations of Oxygen with Sulphur and Phosphorus ; and of the Sulphats and Phosphats.

Mrs. B.

In addition to the general survey which we have tak-n of acids, I think you will find it interesting to ex-mine individually a few of the most important of them, nd likewise some of their principal combinations with he alkalies, alkaline earths, and metals. The first of he acids, in point of importance, is the SULPHURIC, ormerly called *oil of vitriol*.

Caroline. I have known it a long time by that name, ut had no idea that it was the same fluid as sulphuric cid. What resemblance or connection can there be etween oil of vitriol and this acid ?

Mrs. B. Vitriol is the common name for sulphat of on, a salt which is formed by the combination of sul-huric acid and iron ; the sulphuric acid was formerly btained by distillation from this salt, and it very na-rally received its name from the substance which af-rded it.

Caroline. But it is still usually called oil of vitriol ?

Mrs. B. Yes ; a sufficient length of time has not

yet elapsed, since the invention of the new nomenclature, for it to be generally disseminated; but as it is adopted by all scientific chemists, there is every reason to suppose that it will gradually become universal. When I received this bottle from the chemist's, the name written on the label was *oil of vitriol*; but, as I knew you were very punctilious in regard to the nomenclature, I changed it, and substituted the modern name.

Emily. This acid has neither colour nor smell, but it appears much thicker than water.

Mrs. B. It is twice as heavy as water, and has, you see, an oily consistence.

Caroline. And it is probably from this circumstance that it has been called an oil, for it can have no claim to that name, as it does not contain either hydrogen or carbone, which are the essential constituents of oil.

Mrs. B. Certainly; and therefore it would be the more absurd to retain a name which owed its origin to such mistaken analogy.

Sulphuric acid, in its purest state, would be a concrete substance, but its attraction for water is such, that it is impossible to preserve it in that state; it is, therefore, always seen in a liquid form, such as you here find it. One of the most striking properties of sulphuric acid is that of evolving a considerable quantity of heat when mixed with water; this I have already shewn you.

Emily. Yes, I recollect it; but what was the degree of heat produced by that mixture?

Mrs. B. The thermometer may be raised by it to 300, which is considerably above the degree of boiling water.

Caroline. Then water might be made to boil in that mixture.

Mrs. B. Nothing more easy, provided that you employ sufficient quantities of acid and of water, and in the due proportions. The greatest heat is produced by a mixture of one part of water to four of the acid: we shall make a mixture of these proportions, and immerse this thin glass tube, which is full of water, in it.

ine. The vessel feels extremely hot, but the
oes not boil yet.

B. You must allow some time for the heat to
e the tube, and raise the temperature of the
the boiling point—

ine. Now it boils—and with increasing vi-

B. But it will not continue boiling long; for
xture gives out heat only while the particles of
er and the acid are mutually penetrating each
as soon as the new arrangement of those parti-
effected, the mixture will gradually cool, and
er return to its former temperature.

have seen the manner in which sulphuric acid
oses all combustible substances, whether ani-
getable, or mineral, and burns them by means
ygen?

ine. I have very unintentionally repeated the
ient on my gown, by letting a drop of the acid
n it, and it has made a stain, which, I suppose,
er wash out.

B. No, certainly; for, before you can put it in
er, the spot will become a hole, as the acid
ally burnt the muslin.

ine. So it has indeed! Well, I will fasten the
and put the bottle away, for it is a dangerous
ce—Oh, now I have done worse still, for I have
ne on my hand!

B. It is then burned, as well as *your gown*,
know that oxygen destroys animal as well as
le matter; and, as far as the *decomposition* of
of your finger is effected, there is *no remedy*;
washing it immediately in water, you will di-
acid, and prevent any farther injury.

ine. It feels extremely hot, I assure you.

B. You have now learned, by experience,
itiously this acid must be used. You will soon
acquainted with another acid, the nitric, which
it produces less heat on the skin, destroys it still
, and makes upon it an indelible stain. You
ever handle any substances of this kind, with-

out previously dipping your fingers in water, will weaken their caustic effects.—But since y not repeat the experiment, I must put in the s for the acid attracts the moisture from the atmo which would destroy its strength and purity.

Emily. Pray how can sulphuric acid be e from sulphat of iron by distillation?

Mrs. B. The process of distillation, you kno sists in separating substances from one another b of their different degrees of volatility, and by t duction of a new chemical agent, caloric. sulphat of iron be exposed in a retort to a pr gree of heat, it will be decomposed, and the s acid will be volatilized.

Emily. But now that the process of formi by the combustion of their radicals is known, wh not this method be used for making sulphuric

Mrs. B. This is actually done in most manu but the usual method of preparing sulphuric a not consist in burning the sulphur in oxygen we formerly did by way of experiment), but in it together with another substance, nitre, whic oxygen in sufficient abundance to render the co in common air rapid and complete.

Caroline. This substance, then, answers t purpose as oxygen gas?

Mrs. B. Exactly. In manufactures the co is performed in a leaden chamber, with wa bottom, to receive the vapour, and assist its tion. The combustion is, however, never sc but that a quantity of sulphurous acid is form same time; for you recollect that the sulphu differs from the sulphuric only by containing gen.

From its own powerful properties, and fro rious combinations into which it enters, sulph is of great importance in many of the arts.

It is used also as a medicine in a state of g tion; for were it taken internally, in a con state, it would prove a most dangerous poison

Caroline. I am sure it would burn the ach.

B. Can you think of any thing that would
n antidote to this poison ?

ine. A large draught of water to dilute it.

B. That would certainly weaken the power of
, but it would increase the heat to an intolera-
ree. Do you recollect nothing that would de-
; deleterious properties more effectually ?

y. An alkali might, by combining with it ; but
pure alkali is itself a poison, on account of its
ty.

B. There is no necessity that the alkali should
tic. Soap, in which it is combined with oil : or
ia, either in a state of carbonat, or mixed with
would prove the best antidotes.

i. In those cases, then, I suppose, the potash
magnesia would quit their combinations to form
th the sulphuric acid ?

B. Precisely.

nay now make a few observations on the sul-
acid, which we have found to be the product of
slowly and imperfectly burnt.—This acid is dis-
ied by is pungent smell, and its gaseous form.

ine. Its aeriform state is, I suppose, owing to
aller proportion of oxygen, which renders it
han sulphur*ic* acid ?

B. Probably ; for by adding oxygen to the
acid, it may be converted into the stronger kind.
change of state may also be connected with a
of affinity with regard to caloric.

y. And may sulphurous acid be obtained from
ic acid by a diminution of oxygen ?

B. Yes : it can be done by bringing any com-
substance in contact with the acid. This de-
ition is most easily performed by some of the
; these absorb a portion of the oxygen from the
ic acid, which is thus converted into the sulphu-
id flies off in its gaseous form.

ine. And cannot the sulphurous acid itself be
osed and reduced to sulphur ?

B. Yes ; if this gas be heated in contact with

ny, on which we may try the experiment

Emily. It is the stain of mulberries; almost afraid of exposing my gown to th after seeing the effect which the sulphuri ed on that of Caroline—.

Mrs. B. There is no such danger fro ous; but the experiment must be mad caution! for, during the formation of su by combustion, there is always some s duced.

Caroline. But where is your sulphuro

Mrs. B. We may easily prepare so simply by burning a match; we must firs with a little water, and now hold it in thi tle distance, over the lighted match: th arises from it is sulphurous acid, and the gradually disappears.

Emily. I have frequently taken out means, without understanding the natu cess. But why is it necessary to wet th it is exposed to the acid fumes?

Mrs. B. The moisture attracts and al

a few words of its principal combinations. It unites n all the alkalies, alkaline earths, and metals, to form mpound salts.

Caroline. Pray, give me leave to interrupt you for moment: you have never mentioned any other salts n the compound or neutral salts; is there no other d?

Mrs. B. The term *salt* has been used, from time nemorial, as a kind of general name, for any subnce that has savour, odour, is soluble in water, and stallizable, whether it be of an acid, an alkaline, or npound nature; but the compound salts alone retain t appellation in modern chemistry.

The most important of the salst, formed by the comation of the sulphuric acid, are, first, *sulphat of pot-*, formerly called *sal polychrest*; this is a very bitter, much used in medicine; it is found in the ashes of st vegetables, but it may be prepared artificially by immediate combination of sulphuric acid and pot-. This salt is easily soluble in boiling water. Soility is, indeed, a property, common to all salts; d they always produce cold in melting.

Emily. That must be owing to the caloric which ey absorb in passing from a solid to a fluid form.

Mrs. B. That is, certainly, the most probable exnation.

Sulphat of soda, commonly called Glauber's salt, is other medicinal salt, which is still more bitter than preceding. We must prepare some of these comnds, that you may observe the phenomena which es place during their formation. We need only r some sulphuric acid over the soda which I put inhis glass.

Caroline. What an amazing heat is disengaged. I ught you said that cold was produced by the melting salts!

Mrs. B. But you must observe that we are now *ing* not *melting* a salt. Heat is disengaged during formation of compound salts, because the acid goes a more dense state in the salt than that in which it sted before. A faint light is also emitted, which y sometimes be perceived in the dark.

Emily. If the oxygen, in combining with the li, disengages light and heat, an actual combustion place.

Mrs. B. Not so fast, my dear; recollect tl alkalies are incombustible substances, and incap combining with oxygen singly. They are not a by this principle, unless it presents itself in a ur ion with another body; and, therefore, the co tion of an acid with an alkali cannot be called c tion.

Caroline. Will this sulphat of soda become

Mrs. B. We have not, I suppose, mixed t and the alkali in the exact proportions that are ed for the formation of the salt, otherwise the would have been almost immediately changed lid mass; but, in order to obtain it in crystals, see it in this bottle, it would be necessary first it with water, and afterwards evaporate the wa ring which operation the salt would gradually lize.

Caroline. But of what use is the addition of it is afterwards to be evaporated?

Mrs. B. When suspended in water, the the alkali are more at liberty to act on each ot union is more complete, and the salt assumes t lar form of crystals during the slow evaporati solvent.

Sulphat of soda liquefies by heat, and efflo the air.

Emily. Pray what is the meaning of the w *resces?* I do not recollect your having mentio fore.

Mrs. B. A salt is said to effloresce when i water of crystallization on being exposed to tl phere, and is thus gradually converted into a der: you may observe that these crystals of s soda are far from possessing the transparen belongs to their crystalline state; they are with a white powder, occasioned by their hav exposed to the atmosphere, which has depri surface of its lustre, by absorbing its water o

on. Salts are, in general, either *efflorescent* or *de-scent*; this latter property is precisely the reverse he former; that is to say, deliquescent salts absorb er from the atmosphere, and are moistened and dually melted by it. Muriat of lime is an instance reat deliquescence.

mily. But are there no salts that have the same ree of attraction for water as the atmosphere, and will consequently not be affected by it?

Mrs. B. Yes; there are many such salts; as, for ance, common salt, sulphat of magnesia, and a ety of others.

ulphat of lime is very frequently met with in nature, constitutes the well known substance called *gyp-* or *plaster of Paris*.

ulphat of magnesia, commonly called *Epsom salt*, is her very bitter medicine, which is obtained from water and from several springs, or may be prepar- by the direct combination of its ingredients.

Ve have formerly mentioned *sulphat of alumine* as stituting the common alum; it is found in nature fly in the neighborhood of volcanos, and is particu- y useful in the arts, from its strong astringent qua- s. It is chiefly employed by dyers and calico-print- to fix colours; and is used also in the manufacture eather.

Sulphuric acid combines also with the metals.

Caroline. One of these combinations, *sulphat of iron*, are already well acquainted with.

Mrs. B. That is the most important metallic salt med by sulphuric acid, and the only one that we ll here notice. It is of great use in the arts; and medicine, it affords a very valuable tonic: it is of salt that most of those preparations called *steel me- ines* are composed.

Caroline. But does any carbone enter into these npositions to form steel?

Mrs. B. Not an atom; they are, therefore, very properly called steel; but it is the vulgar appella- , and medical men themselves often comply with general custom.

Sulphat of iron may be prepared, as you have seen, by dissolving iron in sulphuric acid; but it is generally obtained from the natural production called *Pyrites*, which, being a sulphuret of iron, requires only exposure to the atmosphere to be oxydated, in order to form the salt; this, therefore, is much the most easy way of procuring it on a large scale.

Emily. I am surprised to find that both acids and compound salts are generally obtained from their various combinations, rather than from the immediate union of their ingredients.

Mrs. B. Were the simple bodies always at hand, their combination would naturally be the most convenient method of forming compounds; but you must consider that, in most instances, there is great difficulty and expense in obtaining the simple ingredients from their combinations; it is, therefore, often more expedient to procure compounds from the decomposition of other compounds. But to return to the sulphat of iron. There is a certain vegetable acid called *Gallic acid*, which has the remarkable property of precipitating this salt black.—I shall pour a few drops of the gallic acid into this solution of sulphat of iron—

Caroline. It is become as black as ink!

Mrs. B. And it is ink in reality. Common writing ink is a precipitate of sulphat of iron by gallic acid; the black colour is owing to the formation of gallat of iron, which being insoluble, remains suspended in the fluid.

This acid has also the property of altering the colour of iron in its metallic state. You may frequently see its effects on the blade of a knife that has been used to cut certain kinds of fruits.

Caroline. True; and that is perhaps the reason that a silver knife is preferred to cut fruits; the gallic acid, I suppose, does not act upon silver.—Is this acid found in all fruits?

Mrs. B. It is contained, more or less, in the rind of most fruits and roots, especially the radish, which if scraped with a steel or iron knife, has its bright red colour changed to a deep purple, the knife being at the

ne blackened. But the vegetable substance in
ıe gallic acid most abounds is *nutgall*, a kind of
:nce that grows on oaks, and from which the
:ommonly obtained for its various purposes.

B. We now come to the PHOSPHORIC and
ɔROUS ACIDS. In treating of phosphorus, you
:n how these acids may be obtained from it by
ion?

. Yes; but I should be much surprised if it
usual method of obtaining them, since it is so
icult to procure phosphorus in its pure state.

B. You are right, my dear; the phosphoric
: general purposes, is extracted from bones,
ı it is contained in the state of phosphat of lime;
s salt the phosphoric acid is separated by means
ıulphuric, which combines with the lime. In
state, phosphoric acid is either liquid or solid,
ıg to its degree of concentration.

ıgst the salts formed by this acid, *phosphat of*
he only one that affords much interest; and this,
: already observed, constitutes the basis of all
It is also found in very small quantities in some
les.

Conversation XV.

*itric and carbonic acids; or the combinations of ox-
with nitrogen and carbone; and of the nitrats and
ıats.*

Mrs. B.

almost afraid of introducing the subject of the
ACID, as I am sure that I shall be blamed by
:, for not having made her acquainted with it

ne. Why so, Mrs. B—?

your censure, Caroline; for I dare sa
had some very good reason for not ment
sooner.

Mrs. B. I do not know whether yo
reason sufficiently good to acquit me;
sion, I assure you, did not proceed fr
You may recollect that nitrogen was one
ple bodies which we examined; you w
rant of the theory of combustion, which
for the first time, mentioned in that less
fore it would have been in vain, at that
attempted to explain the nature and forn

Caroline. I wonder, however, that i
red to us to inquire whether nitrogen cou
for, as we knew it was classed among
tible bodies, it was natural to suppose th
duce an acid.

Mrs. B. That is not a necessary co
it might combine with oxygen only in
quisite to form an oxyd. But you will
gen is susceptible of various degrees
some of which convert it merely into an

B. This acid contains a greater abundance of than any other, but it retains it with very little

y. Then it must be a powerful caustic, both e facility with which it parts with its oxygen, and ntity which it affords?

B. Very well, Emily; both cause and effect ctly such as you describe: nitric acid burns and s all kinds of organized matter. It even sets ome of the most combustible substances. We ur a little of it over this piece of dry warm char- ou see it inflames it immediately; it would do e with oil of turpentine, phosphorus, and seve- er very combustible bodies. This shews you sily this acid is decomposed by combustible bo- nce these effects must depend upon the absorp- ts oxygen.

: acid has been used in the arts from time im- al, but it is not more than twenty five years that mical nature has been ascertained. The cele- Mr. Cavendish discovered that it consisted of) parts of nitrogen, and 25 of oxygen.* These es, in their gaseous state, combine at a high ture; and this may be effected by repeatedly the electrical spark through a mixture of the ses.

/. The nitrogen and oxygen gasses, that com- : atmosphere, do not combine, I suppose, be- eir temperature is not sufficiently elevated?

ine. But in a thunder storm, when the light- peatedly passes through them, may it not pro- ric acid; we should be in a strange situation if : storm should at once convert the atmosphere ic acid.

B. There is no danger of it my dear; the g can affect but a very small portion of the at- re, and though it were occasionally to produce itric acid, yet this never could happen to such s to be perceivable.

proportions stated by Mr. Davy, in his Chemical Re- *re as 1 to 2.* 389.

Emily. But how could the nitric acid be known used, before the method of combining its constit was discovered?

Mrs. B. Before that period the nitric acid wa tained, and it is indeed still extracted for the com purposes of art, from the compound salt which it f with potash, commonly called *nitre*.

Caroline. Why is it called so? Pray, Mrs. l these old unmeaning names be entirely given u us at least; and let us call this salt *nitrat of potash*

Mrs. B. With all my heart; but it is necessar I should, at least, mention the old names, and especially those that are yet in common use; othe when you meet with them, you would not be a understand their meaning.

Emily. And how is the acid obtained from thi

Mrs. B. By the intervention of sulphuric acid, combines with the potash, and sets the nitric liberty. This I can easily shew you, by mixing nitrat of potash and sulphuric acid in this reto heating it over a lamp; the nitric acid will com in the form of vapour, which we shall collect in bell. This acid diluted in water is commonly *aqua fortis*, if Caroline will allow me to menti name.

Caroline. I have often heard that aqua fortis solve almost all metals; it is no doubt because i its oxygen so easily.

Mrs. B. Yes; and from this powerful solv perty, it derived the name of aqua fortis, or str ter. Do you not recollect that we oxydated, ar wards dissolved some copper in this acid?

Emily. If I remember right, the nitrat of was the first instance you gave us of a compoun

Caroline. Can the nitric acid be completely posed and converted into nitrogen and oxygen

Emily. That cannot be the case, Carolin the acid can be decomposed only by the combi its constituents with other bodies.

Mrs. B. True; but caloric is sufficient for ose. By making the acid pass through a re

ain tube, it is decomposed; the nitrogen and oxy- n regain the caloric which they had lost in combin-, and are thus both restored to their gaseous state.

The nitric acid may also be partly decomposed, and by this means converted into NITROUS ACID.

Caroline. This conversion must be easily effected, the oxygen is so slightly combined with the nitrogen.

Mrs. B. The partial decomposition of nitric acid is adily effected by most metals; but it is sufficient to pose the nitric acid to a very strong light to make it e out oxygen gas, and be thus converted into nitrous d. Of this acid there are various degrees, accord- to the proportions of oxygen which it contains; strongest and that into which the nitric acid is first nverted, is of a yellow colour, as you see it in this bot-

Caroline. How it fumes when the stopper is taken t.

Mrs. B. The acid exists naturally in a gaseous state, d is here so strongly concentrated in water that it is nstantly escaping.

Here is another bottle of nitrous acid, which, you e is of an orange red colour; this acid is weaker, the trogen being combined with a smaller quantity of ox- gen; and with a still less proportion of oxygen it is olive green colour, as it appears in this third bottle. short, the weaker the acid, the deeper is its colour.

Nitrous acid acts still more powerfully on some in- mmable substances than the nitric.

Emily. I am surprised at that, as it contains less ygen.

Mrs. B. But, on the other hand, it parts with its ygen much more readily: you may recollect that we ice inflamed oil with this acid.

The next combinations of nitrogen and oxygen form ly oxyds of nitrogen, the first of which is common- called *nitrous air:* or more properly *nitric oxyd gas.* his may be obtained from nitric acid, by exposing e latter to the action of metals, as in dissolving them does not yield the whole of its oxygen, but retains a ortion of this principle sufficient to convert it into this

peculiar gas, a specimen of which I have prepared and preserved within this inverted glass bell.

Emily. It is a perfectly invisible elastic fluid.

Mrs. B. Yes; and it may be kept any length of time in this manner over water, as it is not, like the nitric and nitrous acids, absorbable by it. It is rather heavier than atmospherical air, and is incapable of supporting either combustion or respiration. I am going to incline the glass gently on one side, so as to let some of the gas escape—

Emily. How very curious!—It produces orange fumes like the nitrous acid! that is the more extraordinary, as the gas within the glass is perfectly invisible.

Mrs. B. It would give me much pleasure if you could make out the reason of this curious change without requiring any further explanation.

Caroline. It seems, by the colour and smell, as if it were converted into nitrous acid gas: yet that cannot be, unless it combines with more oxygen; and how can it obtain oxygen the very minute it escapes from the glass?

Emily. From the atmosphere, no doubt. Is it not so, Mrs. B.?

Mrs. B. You have guessed it; as soon as it comes in contact with the atmosphere it absorbs from it the additional quantity of oxygen necessary to convert it into nitrous acid gas.—And, if I now remove the bottle entirely from the water, so as to bring at once the whole of the gas into contact with the atmosphere, this conversion will appear still more striking.

Emily. Look, Caroline, the whole capacity of the bottle is instantly tinged of an orange colour!

Mrs. B. Thus you see it is the most easy process imaginable to convert *nitrous oxyd gas* into *nitrous acid gas.* The property of attracting oxygen from the atmosphere, without any elevation of temperature, has occasioned this gaseous oxyd being used as a test for ascertaining the degree of purity of the atmosphere. I am going to show you how it is applied to this purpose —You see this graduated glass tube, which is closed at one end; (*Plate* VIII. Fig. 19.)—I first fill it with

r, and then introduce a certain measure of nitrous which, not being absorbable by water, passes thro' nd occupies the upper part of the tube. I must add rather above two thirds of oxygen gas, which just be sufficient to convert the nitric oxyd gas, in- trous acid gas.

roline. So is has !—I saw it turn of an orange co- ; but it immediately afterwards disappeared entire- nd the water, you see, has risen, and almost filled ube.

rs. B. That is because the acid gas is absorbable ater, and in proportion as the gas impregnates the , the latter rises in the tube. When the oxygen s very pure, and the required proportion of nitric gas very exact, the whole is absorbed by the wa- but if any other gas be mixed with the oxygen, d of combining with the nitric oxyd, it will remain ccupy the upper part of the tube ; or, if the gas- e not in the due proportion, there will be a residue at which predominates.—Before we leave this sub- I must not forget to remark, that nitric acid may rmed by dissolving nitric oxyd gas in nitric acid. solution may be effected simply by making bubbles tric oxyd gas pass through nitric acid.

nily. That is to say, that nitrogen, at its highest e of oxygenation, being mixed with nitrogen at west degree of oxygenation, will produce a kind of mediate substance, which is nitric acid.

rs. B. You have stated the fact with great preci- —There are various other methods of preparing s oxyd, and of obtaining it from compound bodies ; is not necessary to enter into these particulars. It ins for me only to mention another curious modifi- n of oxygenated nitrogen, which has been distin- ed by the name of *gaseous oxyd of nitrogen.* It is ately that this gas has been accurately examined, ts properties have been chiefly investigated by Mr. . It has obtained also the name of *exhilirating* from the very singular property which that gentle- has discovered in it, of elevating the animal spirits, inhaled into the lungs, to a degree sometimes re- *ling delirium or intoxication.*

Caroline. It is respirable, then ?

Mrs. B. It can scarcely be called respirable, as it would not support life for any length of time; but it may be breathed for a few moments without any other effects, than the singular exhiliration of spirits I have just mentioned. It affects different people, however, in a very different manner. Some become violent, even outrageous: others experience a languor, attended with faintness; but most agree in opinion, that the sensations it excites are extremely pleasant.

Caroline. I think I should like to try it—how do you breath it ?

Mrs. B. By collecting the gas in a bladder, to which a short tube with a stop-cock is adapted; this is applied to the mouth with one hand, whilst the nostrils are kept closed with the other, that the common air may have no access. You then alternately inspire, and expire the gas, till you perceive its effects. But I cannot consent to your making the experiment; for the nerves are sometimes unpleasantly affected by it, and I would not run any risk of that kind.

Emily. I should like, at least, to see somebody breathe it; but pray by what means is this curious gas obtained ?

Mrs. B. It is procured from *nitrat of ammonia*, an artificial salt, which yields this gas on the application of a gentle heat—I have put some of the salt into a retort, and by the aid of a lamp the gas will be extricated—

Caroline. Bubbles of air begin to escape through the neck of the retort into the water apparatus; will you not collect them ?

Mrs. B. The gas that first comes over is never preserved, as it consists of little more than the common air which was in the retort; besides, there is always in this experiment a quantity of watery vapour which must come away before the nitrous oxyd appears.

Emily. Watery vapour! Whence does that proceed ? there is no water in nitrat of ammonia !

Mrs. B. You must recollect that there is in every salt a quantity of water of crystallization, which may be

-porated by heat alone. But, besides this, water is -ually generated in this experiment, as you will see -sently. But first tell me, what are the constituent -ts of nitrat of ammonia?

Emily. Ammonia, and nitric acid: this salt, there-, contains three different elements, nitrogen and -drogen, which produce the ammonia; and oxygen, -ich, with nitrogen, forms the acid.

Mrs. B. Well, then, in this process the ammonia -decomposed; the hydrogen quits the nitrogen to com- -e with some of the oxygen of the nitric acid, and -ms with it the watery vapour which is now coming -er. When that is effected, what will you expect to -d?

Emily. Nitrous acid instead of nitric acid, and ni- -gen instead of ammonia.

Mrs. B. Exactly so; and the nitrous acid, and ni- -gen combine, and form the gaseous oxyd of nitro- -n, in which the proportion of oxygen is 37 parts to - of nitrogen.

You may have observed, that for a little while no bub- -es of air have come over, and we have perceived on- a stream of vapour condensing as it issued into the -ater.—Now bubbles of air again make their appear- -nce, and I imagine that by this time all the watery -apour is come away, and that we may begin to collect -e gas. We may try whether it is pure by filling a -hial with it, and plunging a taper into it—yes, it will -o now, for the taper burns brighter than in the com- -on air, and with a greenish flame.

Caroline. But how is that? I thought no gas would -pport combustion but oxygen.

Mrs. B. Or any gas that contains oxygen, and is -eady to yield it, which is the case with this in a con- -derable degree; it is not, therefore, surprising that should accelerate the combustion of the taper.

You see that the gas is now produced in great abun- -ance; we shall collect a large quantity of it, and I -are say we shall find some of the family who will be -urious to make the experiment of respiring it. Whilst -is process is going on, we may take a general survey

of the most important combination of the nitric a trous acids with the alkalies.

The first of these is *nitrat of potash*, commonl ed *nitre*, or *saltpetre*.

Caroline. Is not that the salt with which gunp is made ?

Mrs. B Yes. Gunpowder is a mixture parts of nitre to one of sulphur, and one of char Nitre from its great proportion of oxygen, and the facility with which it yields it, is the basis o detonating compositions.

Emily. But what is the cause of the violent d tion of gunpowder when set fire to ?

Mrs. B. Detonation may proceed from two c the sudden formation or destruction of an elasti In the first case, when either a solid or liquid is taneously converted into an elastic fluid, the pro and sudden expansion of the body strikes the ai great violence, and this concussion produces the called detonation.

Caroline. That I comprehend very well ; b can a similar effect be produced by the destructi gas ?

Mrs. B. A gas can be destroyed only by co ing it to a liquid or solid state ; when this take suddenly, the gas, in assuming a new and mor pact form, produces a vacuum into which the su ing air rushes with great impetuosity ; and it is rapid and violent motion that the sound is prod In all detonations, therefore, gasses are either ly formed, or destroyed. In that of gunpowd you tell me which of these two circumstance place ?

Emily. As gunpowder is a solid, it must, of produce the gasses in its detonation ; but how, not tell.

Mrs. B. The constituents of gunpowder, heated to a certain degree, enter into a number combinations, and are instantaneously converte variety of gasses, the sudden expansion of whic rise to the detonation.

aroline. And in what instance does the destruction ondensation of gasses produce detonation?

Irs. B. I can give you one with which you are acquainted; the sudden combination of the oxygen hydrogen gasses.

aroline. True; I recollect perfectly that hydrogen nates with oxygen when the two gasses are con-ed into water.

Irs. B. But let us return to the nitrat of potash. s salt is decomposed when exposed to heat, and ed with any combustible body, such as carbone, hur, or metals, these substances oxydating rapidly he expense of the nitrat. I must shew you an in-ce of this.—I expose to the fire some of the salt in nall iron ladle, and when it is sufficiently heated, to it some powdered charcoal; this will attract the gen from the salt, and be converted into carbonic l—

Emily. But what occasions that crackling noise, and se vivid flashes that accompany it?

Mrs. B. The rapidity with which the carbonic acid is formed, occasions a succession of small detona-ns, which, together with the emission of flame, is led *deflagration.*

Nitrat of ammonia we have already noticed, on ac-nt of the gaseous oxyd of nitrogen which is obtained m it.

Nitrat of silver is the lunar caustic, so remarkable its property of destroying animal fibre, for which rpose it is often used by surgeons.—We have said much on a former occasion, on the mode in which ustics act on animal matter, that I shall not detain u any longer on this subject.

We now come to the CARBONIC ACID, which we ve already had many opportunities of noticing. You collect that this acid may be formed by the combus-n of carbone whether in its imperfect state of char-al, or in its purest form of diamond. And it is not

necessary, for this purpose, to burn the carbo pure oxygen gas, as we did in a preceding lectur you need only light a piece of charcoal and sus under the receiver on the water bath. The c will soon be extinguished, and the air in the r will be found mixed with carbonic acid, the however, is much more expeditious if the combu performed in pure oxygen gas.

Caroline. But how can you separate the acid, obtained in this manner, from the air wit it is mixed.

Mrs. B. The readiest mode is to introdu the receiver, a quantity of caustic lime, or ca kali, which soon attracts the whole of the carb to form a carbonat.—The alkali is found inc weight, and the volume of the air is diminis quantity equal to that of the carbonic acid w mixed with it.

Emily. Pray is there no method of obtain carbone from carbonic acid?

Mrs. B. For a long time it was supposed t bonic acid was not decomposable; but Mr. discovered, a few years ago, that this acid ma composed by burning phosphorus in a close with carbone of soda or carbonat of lime: t phorus absorbs the oxygen from the carbona the carbone is separated in the form of a black

Caroline. Cannot we make that experiment

Mrs. B. Not easily; it requires being pe with extreme nicety, in order to obtain any quantity of carbone, and the experiment is n delicate for me to attempt it. But there ca doubt of the accuracy of Mr. Tennant's resu all chemists now agree, that 100 parts of carb gas consist of about 28 parts of carbone to 72 o gas.

Carbonic acid gas is found very abundantly in it is supposed to form about a hundredth pa atmosphere, and is constantly produced by the tion of animals; it exists in a great variety of tions, and is exhaled from many natural decom

contained in a state of great purity in certain caves, h as the *Grotto del Cane*, near Naples.

Emily. I recollect having read an account of that tto, and of the cruel experiments made on the poor s, to gratify the curiosity of strangers. But I unstood that the vapour exhaled by this cave was call. *fixed air*.

Mrs. B. That is the name by which carbonic acid known before its chemical composition was discovd.—This gas is more destructive of life than any er; and if the poor animals that are submitted to effects, are not plunged into cold water as soon as y become senseless, they do not recover. It extinshes flame instantaneously. I have collected some his glass, which I will pour over the candle.

Caroline. This is extremely singular—it seems to nguish it as it were by enchantment, as the gas is sible. I never should have imagined that a gas d have been poured like a liquid.

Mrs. B. It can be done with carbonic acid only, as ther gas is sufficiently heavy to be susceptible of bepoured out in the atmospherical air, without mixwith it.

Emily. Pray by what means did you obtain this gas?

Mrs. B. I procured it from marble. Carbonic acid has so strong an attraction for all the alkalies and line earths, that these are always found in nature in state of carbonats. Combined with lime, this acid is chalk, which may be considered as the basis of inds of marble, and calcareous stones. From these tances carbonic acid is easily separated, as it ades so slightly to its combinations, that the carbonats all decomposable by any of the other acids. I can ly shew you how I obtained this gas; I poured some ted sulphuric acid over pulverized marble in this le (the same which we used the other day to pree hydrogen gas), and the gas escaped through the e connected with it; the operation still continues, as may easily perceive—

Emily. Yes, it does; there is a great fermentation he glass vessel. What singular commotion is ex-

cited by the sulphuric acid taking possession of the lime, and driving out the carbonic acid?

Caroline. But did the carbonic acid exist in a gaseous state in the marble?

Mrs. B. Of course not; the acid, when in a state of combination, is capable of existing in a solid form.

Caroline. Whence, then, does it obtain the caloric necessary to convert it into a gas?

Mrs. B. It may be supplied in this case from the mixture of sulphuric acid and water, which produces an evolution of heat, even greater than is required for the purpose; since, as you may perceive by touching the glass vessel, a considerable quantity of the caloric disengaged becomes sensible. But a supply of caloric may be obtained also from a diminution of capacity for heat, occasioned by the new combination which takes place; and, indeed, this must be the case when other acids are employed for the disengagement of carbonic acid gas, which do not, like the sulphuric, produce heat on being mixed with water. Carbonic acid may likewise be disengaged from its combinations by heat alone, which restores it to its gaseous state.

Caroline. It appears to me very extraordinary that the same gas, which is produced by the burning of wood and coals, should exist also in stones, marble, and chalk, which are incombustible substances.

Mrs. B. I will not answer that objection, Caroline, because I think I can put you in a way of doing it yourself. Is carbonic acid combustible?

Caroline. Why, no—because it is a body that has been already burnt, it is carbone only, and not the acid that is combustible.

Mrs. B. Well, and what inference do you draw from this?

Caroline. That carbonic acid cannot render the bodies in which it is contained combustible; but that simple carbone does, and that it is in this elementary state that it exists in wood, coals, and a great variety of other combustible bodies.—Indeed, Mrs. B. you are very ungenerous; you are not satisfied with convincing me

: my objections are frivolous, but you oblige me to ve them so myself.

Mrs. B. You must confess, however, that I make ple amends for the detection of error, when I enable to discover the truth. You understand, now, I hope, : carbonic acid is equally produced by the decompo- on of chalk, or by the combustion of charcoal. These cesses are certainly of a very different nature ; in first case the acid is already formed, and requires hing more than heat to restore it to its gaseous state ; ist, in the latter, the acid is actually formed by the cess of combustion.

Caroline. I understand it now perfectly. But I have been thinking of another difficulty, which I hope will excuse my not being able to remove myself. w does the immense quantity of calcareous earth, ch is spread all over the globe, obtain the carbonic l which is combined with it ?

Mrs. B. This question is, indeed, not very easy to wer ; but I conceive that the general carbonization alcareous matter may have been the effect of a gen- l combustion, occasioned by some revolution of our be, and producing an immense supply of carbonic l, with which the calcareous matter became impreg- ed ; or that this may have been effected by a gradu- ibsorption of carbonic acid from the atmosphere.— t this subject would lead us to discussions which we not indulge in, without deviating too much from our ject.

Emily. How does it happen that we do not perceive pernicious effects of the carbonic acid that is float- in the atmosphere ?

Mrs. B. Because of the state of very great dilution which it exists there. But can you tell me, Emily, at are the sources which keep the atmosphere con- ntly supplied with this acid ?

Emily. I suppose the combustion of wood, coals, l other substances, that contain carbone.

Mrs. B. And also the breath of animals.

Caroline. The breath of animals ! I thought you d *that this gas* was not at all respirable, but, on the *trary, extremely* poisonous.

such a deadly poison ?

Mrs. B. The manner in which t
life, seems to be merely by preventin
respirable air ; for carbonic acid gas,
diluted with common air, does not p
lungs, as the windpipe actually contr
it admittance.—But we must dismiss t
sent, as we shall have an opportunity
spiration much more fully, when we c
ical functions of animals.

Emily. Is carbonic acid as destru
vegetables, as it is to that of animals

Mrs. B. If a vegetable be comple
it, I believe it generally proves fatal
in certain proportions with atmospheic
contrary, very favourable to vegetatio

You remember, I suppose, our me
eral waters, both natural and artifici
carbonic acid gas ?

Caroline. You mean the Seltzer w

Mrs. B. That is one of those whi
there are, however, a variety of othe

st always found combined with it; and you may lect that it is only by separating them from this that they acquire that causticity and those striking ties which I have formerly described. All mar- chalks, shells, calcareous spars, and lime-stones very description, are neutral salts, in which *lime*, common basis, has lost all its characteristic pro- es.

mily. But if all these various substances are form- y the union of lime with carbonic acid, whence s their diversity of form and appearance?

Mrs. B. Both from the different proportions of their ponent parts, and from a variety of foreign ingre- ts which may be occasionally mixed with them: veins and colours of marble, for instance, proceed a mixture of metallic substances; silex and alu- e also frequently enter into these combinations. various carbonats therefore, that I have enumerat- cannot be considered as pure unadulterated neutral s, although they certainly belong to that class of es.

Conversation XVI.

n the muriatic and oxygenated muriatic acids; and on muriats.

Mrs. B.

We come now to the undecompounded acids.—The riatic, formerly called the marine acid, is the y one that requires our particular attention.

The basis of this acid, as I have told you before, is nown, all attempts to decompose it having hitherto

proved fruitless ; it is, therefore, by analogy on
we suppose it to consist of a certain substance or
combined with oxygen.

Caroline. It can then never be formed by t
bination of simple bodies, but must always b
from its compounds.

Emily. Unless the acid should be found
uncombined with other substances.

Mrs. B. I believe that is never the case.
cipal combinations are with soda, lime, and m
Muriat of soda, is the common sea salt, and
substance the acid is usually disengaged by
the sulphuric acid. The natural state of the
acid, is that of an invisible permanent gas, at
mon temperature of the atmosphere ; but it h
tremely strong attraction for water, and ass
form of a whitish cloud, whenever it meets
moisture to combine with. This acid is rema
its peculiar and very pungent smell, and pos
a powerful degree, most of the acid propertie
is a bottle containing muriatic acid in a liquid

Caroline. And how is it liquified ?

Mrs. B. By impregnating water with it ;
attraction for water makes it very easy to c
a liquid form. Now, if I open the phial, yo
serve a kind of vapour rising from it, which i
acid gas, of itself invisible, but made apparen
bining with the moisture of the atmosphere.

Emily. Have you not any of the pure mu
gas ?

Mrs. B. This jar is full of that acid in i
state—it is inverted over mercury instead of
cause, being absorbable by water, this gas
confined by it.—I shall now raise the jar a lit
side, and suffer some of the gas to escape.–
that it immediately becomes visible in the
cloud.

Emily. It must be, no doubt, from its un
the moisture of the atmosphere, that it is con
to this dewy vapour.

Mrs. B. Certainly; and for the same reason, that is to say, its extreme eagerness to unite with water, this gas will cause snow to melt as rapidly as an intense fire.

Emily. Since this acid cannot be decomposed, I suppose that it is not susceptible of different degrees of oxygenation?

Mrs. B. You are mistaken in your conclusion; for though we cannot deoxygenate this acid, yet we may add oxygen to it.

Caroline. Why then is not the least degree of oxygenation of the acid, called the *muriatous*, and the higher degree the *muriatic* acid?

Mrs. B. Because, instead of becoming, like other acids, more dense, and more acid by an addition of oxygen, it is rendered on the contrary more volatile, more pungent, but less acid, and less absorbable by water. These circumstances, therefore, seem to indicate the propriety of making an exception to the nomenclature. The highest degree of oxygenation of this acid has been distinguished by the additional epithet of *oxygenated*, or, for the sake of brevity, *oxy*, so that it is called the *oxygenated*, or *oxy-muriatic acid*. This likewise exists in a gaseous form, at the temperature of the atmosphere; it is also susceptible of being absorbed by water, and can be congealed, or solidified, by a certain degree of cold.

Emily. And how do you obtain the oxy-muriatic acid?

Mrs. B. By distilling liquid muriatic acid over oxyd of manganese, which supplies the acid with the additional oxygen. One part of the acid being put into a retort, with too parts of the oxyd of manganese, and the heat of a lamp applied, the gas is soon disengaged, and may be received over water, as it is but sparingly absorbed by it. I have collected some in this jar—

Caroline. It is not invisible, like the generality of gasses; for it is of a yellowish colour.

Mrs. B. The muriatic acid extinguishes flame, whilst, on the contrary, the oxy-muriatic makes the flame larger, and gives it a dark red colour. Can you account for this difference in the two acids?

Emily. Yes, I think so; the muriatic acid cannot be decomposed, and therefore will not supply the flame with the oxygen necessary for its support; but when this acid is farther oxygenated it will part with its additional quantity of oxygen, and in this way support combustion.

Mrs. B. That is exactly the case; indeed the oxygen, added to the muriatic acid, adheres so slightly to it, that it is separated by mere exposure to the sun's rays. This acid is decomposed also by combustible bodies, many of which it burns, and actually inflames, without any previous increase of temperature.

Caroline. That is extraordinary, indeed! I hope you mean to indulge us with some of these experiments!

Mrs. B. I have prepared several glass jars of oxy-muriatic acid gas, for that purpose. In the first we shall introduce some Dutch gold leaf.—Do you observe that it takes fire?

Emily. Yes, indeed it does—how wonderful it is! it became immediately red hot, but was soon smothered in a thick vapour.

Caroline. Good heavens! what a disagreeable smell!

Mrs. B. We shall try the same experiment with phosphorus in another jar of this acid.—You had better keep your handkerchief to your nose when I open it—now let us drop into it this little piece of phosphorus—

Caroline. It burns really: and almost as brilliantly as in oxygen gas! But what is most extraordinary, these combustions take place without the metal or phosphorus being previously lighted, or even in the least heated.

Mrs. B. All these curious effects are owing to the very great facility with which this acid yields oxygen to such bodies as are strongly disposed to combine with it. It appears extraordinary indeed to see bodies, and metals in particular, melted down and inflamed, by a gas, without any increase of temperature, either of the gas or of the combustible. The phenomenon, however, is, you see, well accounted for.

Emily. Why did you burn a piece of Dutch gold leaf rather than a piece of any other metal?

Mrs. B. Because, in the first place, it is a compo-

n of metals consisting chiefly of copper, which s readily; and I use a thin metallic leaf in prefer- e to a lump of metal, because it offers to the action e gas but a small quantity of matter under a large ace.—Filings, or shavings, would answer the pur- e nearly as well; but a lump of metal, though the ace would oxydate with great rapidity, would not fire. Pure gold is not inflamed by oxy-muriatic gas, but it is rapidly oxydated, and dissolved by indeed, this acid is the only one that will dissolve d.

Emily. This, I suppose, is what is commonly called *a regia*, which you know, is the only thing that will upon gold.

Mrs. B. That is not exactly the case either; for aqua a is composed of a mixture of muriatic and nitric . But, in fact, the result of this mixture is no- g more than oxy-muriatic acid, as the muriatic acid genates itself at the expense of the nitric; this mix- e, therefore, though it bears the name of *nitro mu- ic acid*, acts on gold merely in virtue of the oxy- riatic acid which it contains.

Sulphur, volatile oils, and many other substances, l burn in the same manner in oxy-muriatic acid gas; I have not prepared a sufficient quantity of it, to w you the combustion of all these bodies.

Caroline. Yet there are several jars of the gas re- aining.

Mrs. B. We must reserve these for other experi- nts. The oxy-muriatic acid does not, like other ds, redden the blue vegetable colours; but it totally troys any colour, and turns all vegetables perfectly ite. Let us collect some vegetable substances to into this glass which is full of gas.

Emily. Here is a sprig of myrtle—

Caroline. And here some coloured paper—

Mrs. B. We shall also put in this piece of coque- t ribbon, and a rose—

Emily. Their colours begin to fade immediately! t how does the gas produce this effect?

Mrs. B. The oxygen combines with the colouring

matter of these substances, and destroys it; that is to say, destroys the property which these colours had of reflecting only one kind of rays, and renders them capable of reflecting them all, which, you know, will make them appear white. Old prints may be cleaned by this acid, for the paper will be whitened without injuring the impression, as printer's ink is made of materials (oil and lamp black) which are not acted upon by acids.

This property of the oxy-muriatic acid has lately been employed in manufactories in a variety of bleaching processes; but for these purposes the gas must be dissolved in water, as the acid is thus rendered much milder and less powerful in its effects; for, in a gaseous state, it would destroy the texture, as well as the colour, of the substance submitted to its action.

Caroline. Look at the things which we put into the gas; they have now entirely lost their colour!

Mrs. B. The effect of the acid is almost complete —and, and if we were to examine the quantity that remains, we should find it consist chiefly of muriatic acid.

The oxy-muriatic acid has been used to purify the air in fever hospitals and prisons, as it burns and destroys putrid effluvia of every kind. The infection of the small pox is likewise destroyed by this gas, and matter that has been submitted to its influence will no longer generate that disorder.

Caroline. Indeed, I think the remedy must be nearly as bad as the disease; the oxy-muriatic acid has such a dreadful suffocating smell.

Mrs. B. It is certainly extremely offensive; but by keeping the mouth shut, and wetting the nostrils with liquid ammonia, in order to neutralize the vapour as it reaches the nose, its prejudicial effects may be in some degree prevented. At any rate, however, this mode of disinfection can hardly be used in places that are inhabited. And as the vapour of nitric acid, which is scarcely less efficacious for this purpose, is not at all prejudicial, it is usually preferred on such occasions.

Amongst the compound salts formed by muriatic acid, the *muriat of soda*, or common salt, is the most

esting. The uses and properties of this salt are well known to require much comment. Besides pleasant flavour it imparts to the food, it is very lesome, when not used to excess, as it greatly as- the process of digestion.

a-water is the great source from which the muriat da is extracted by evaporation. But it is found also rge solid masses in the bowels of the earth, in Eng- , and in many other parts of the world.

mily. I thought that salts, when solid, were al- s in a state of crystals; but the common table salt the form of a coarse white powder.

rs. B. Crystallization depends, as you may recol- on the slow and regular reunion of particles dis- ed in a fluid; common sea salt is only in a state of erfect crystallization, because the process by which prepared is not favorable to the formation of regu- rystals. But, if you melt it, and afterwards eva- te the water slowly, you will obtain a regular crys- ation.

uriat of ammonia is another combination of this acid, h we have already mentioned as the principal ce from which ammonia is derived.

can at once shew you the formation of this salt by immediate combination of muriatic acid with ammo- —These two glass jars contain, the one muriatic gas, the other ammoniacal gas, both of which are fectly invisible—now, if I mix them together, you they immediately form an opaque white cloud like ke. If a thermometer were placed in the jar in ch these gasses are mixed, you would perceive that e heat is at the same time produced.

mily. The effects of chemical combinations are, ed, wonderful—how extraordinary it is that two in- ble bodies should become visible by their union.

Mrs. B. This strikes you with wonder because it is henomenon which nature seldom exhibits to our v; but the most common of her operations are as nderful, and it is their frequency only that prevents regarding them with equal admiration. What

would be more surprising for instance, than o
tion, were it not rendered so familiar by custom

Emily. That is true.—But pray, Mrs. B.
white cloud the salt that produces ammonia? H
ferent it is from the solid muriat of ammonia whi
once shewed us!

Mrs. B. It is the same substance which fi
pears in the state of vapour, but will soon be c
ed, by cooling against the sides of the jar, in th
of very minute crystals.

We may now proceed to the *oxy-muriats.*
class of salts the *oxy-muriat of potash* is the mo
thy of our attention, for its striking properties
acid, in this state of combination, contains a stil
er proportion of oxygen than when alone.

Caroline. But how can the oxy-muriatic acid
an increase of oxygen by combining with potas

Mrs. B. It does not really acquire an ad
quantity of oxygen, but it loses some of the m
acid, which produces the same effect, as the a
remains is proportionably super-oxygenated.

If this salt be mixed, and merely rubbed t
with sulphur, phosphorus, charcoal, or ind
other combustible, it explodes strongly.

Caroline. Like gunpowder, I suppose, it is
ly converted into elastic fluids?

Mrs. B. Yes; but with this remarkable dif
that no increase of temperature, any further
produced by the gentle friction, is required in
stance. Can you tell me what gasses are g
by the detonation of this salt with charcoal?

Emily. Let me consider...... The ox
atic acid parts with its excess of oxygen to t
coal, by which means it is converted into muri
gas; whilst the charcoal, being burnt by the
is changed to carbonic acid gas—What becom
potash I cannot tell.

Mrs. B. That is a fixed product which re
the vessel.

Caroline. But since the potash does not en
the new combinations, I do not understand of

this operation. Would not the oxy-muriatic nd the charcoal produce the same effect without

. B. No; because there would not be that very concentration of oxygen which the combination le potash produces, as I have just explained. ean to shew you this experiment, but I would adu not to repeat it alone; for if care be not taken only very small quantities at a time, the detonaill be extremely violent, and may be attended angerous effects. You see I mix an exceedingly quantity of the salt with a little powdered charcoal, Wedgwood mortar, and rub them together with stle—

oline. Heavens! How can such a loud explosion duced by so small a quantity of matter?

. B. You must consider that an extremely small ty of solid substance may produce a very great e of gasses; and it is the sudden evolution of which occasions the sound.

ily. Would not oxy-muriat of potash make strongpowder than nitrat of potash?

. B. Yes; but the preparation as well as the this salt, is attended with so much danger, that ever employed for that purpose.

oline. There is no cause to regret it, I think; common gunpowder is quite sufficiently destruc-

. B. I can shew you a very curious experiment this salt; but it must again be on condition that ill never attempt to repeat it by yourselves. I a small piece of phosphorus into this glass of wahen a little oxy-muriat of potash; and, lastly, I in, by means of this funnel, so as to bring it in t with the two other ingredients in the bottom of ass, a small quantity of sulphuric acid—

oline. This is indeed, a beautiful experiment! osphorus takes fire and burns from the bottom of ter.

ily. How wonderful it is to see flame bursting

reflection you would have discovered a
ring circumstance, which is, that an i
perature is produced by the mixture c
acid and water, which assists in promoti
tion of the phosphorus.

We have now examined such of the a
I conceived would appear to you mos
I shall not enter into any particulars
metallic acids, as they offer nothing su
ing for our present purpose.

Conversation XVI

On the nature and composition of v

vegetable and animal creation ? I have, however, a very vague idea of the word *organization*, and I e often wished to know more precisely what it ans.

Mrs. B. Organized bodies are such as are endow- by nature with various parts, peculiarly constructed adapted to perform certain functions connected life. Thus you may observe, that mineral com- nds are formed by the simple effect of mechanical hemical attraction, and may appear to some to be, great measure, the productions of chance ; whilst anized bodies bear the most striking marks of de- , and are eminently distinguished by that unknown ciple called *life*, from which the various organs de- the power of exercising their respective functions.

aroline. But in what manner does life enable these ans to perform their several functions ?

Irs. B. That is a mystery which, I fear, is envel- d in too profound darkness for us to hope that we l ever be able to unfold it. We must content our- es with examining the effects of this principle ; as he cause, we have been able only to give it a name, out attaching any other meaning to it than the vague unsatisfactory idea of an unknown agent.

aroline. And yet I think I can form a very clear of life.

Irs. B. Pray let us hear how you would define it.

aroline. It is perhaps more easy to conceive than xpress--let me consider--Is not life the power which bles both the animal and vegetable creation to per- n the various functions which nature has assigned to m ?

Irs. B. I have nothing to object to you definition ; you will allow me to observe, that you have only men- ed the effects which the unknown cause produces, out giving us any notion of the cause itself.

mily. Yes, Caroline, you have told us what life , but you have not told us what it *is*.

Irs. B. We may study its operations, but we should zle ourselves to no purpose by attempting to form lea of its real nature.

We shall begin with examining its effects in th etable world, which constitutes the simplest c organized bodies; these we shall find disting from the mineral creation, not only by their mor plicated nature, but by the power which they within themselves, of forming new chemical ar ments of their constituent parts, by means of priate organs. Thus, though all vegetables a mately composed of hydrogen, carbone, and (with a few other occasional ingredients), they s and combine these principles by their various in a thousand ways, and form with them, differe of juices and solid parts, which exist ready n vegetables, and may, therefore, be considered immediate materials.

These are:

Sap	*Resins,*
Mucilage	*Gum Resins,*
Sugar,	*Balsams,*
Fecula,	*Caoutchouc,*
Gluten,	*Extractive colouring*
Fixed Oil,	*Tannin,*
Volatile Oil,	*Woody Fibre,*
Camphor,	*Vegetable Acids, &*

Caroline. What a long list of names! I did pose that a vegetable was composed of half ingredients.

Mrs. B. You must not imagine that every these materials is formed in each individual p only mean to say, that they are all derived exc from the vegetable kingdom.

Emily. But does each particular part of th such as the root, the bark, the stem, the se leaves, consist of one of these ingredients onl several of them combined together?

Mrs. B. I believe there is no part of a pla can be said to consist solely of any one parti gredient; a certain number of vegetable r must always be combined for the formation of ticular part, (of a seed, for instance), and the binations are carried on by sets of vessels,

ans, which select from other parts, and bring to-ther, the several principles required for the develope-nt and growth of those particular parts which they intended to form and to maintain.

Emily. And are not these combinations always reg-ed by the laws of chemical attraction?

Mrs. B. No doubt; the organs of plants cannot e principles to combine that have no attraction for h other; nor can they compel superior attractions ield to those of inferior power; they probably act er mechanically, by bringing into contact such prin-es, and in such proportions, as will by their chemi-combination, form the various vegetable products.

Caroline. We may then consider each of these or-s as a curiously constructed apparatus, adapted for performance of a variety of chemical processes.

Mrs. B. Exactly so. As long as the plant lives and ves, the carbone, hydrogen, and oxygen, (the chief stituents of its immediate meterials), are so balanc-and connected together, that they are not susceptible entering into other combinations; but no sooner does th take place, than this state of equilibrium is de-oyed, and new combinations produced.

Emily. But why should death destroy it; for these nciples must remain in the same proportions, and sequently, I should suppose, in the same order of ractions?

Mrs. B. You must remember, that in the vegeta-, as well as in the animal kingdom, it is by the prin-le of *life* that the organs are enabled to act; when prived of that agent or stimulus, their power ceases, d an order of attractions succeeds similar to that ich would take place in mineral or unorganized mat-.

Emily. It is this new order of attractions, I sup-se, that destroys the organization of the plant after ath; for if the same combinations still continued to evail, the plant would always remain in the state in ich it died.

Mrs. B. And that you know is never the case; ants may be partially preserved for some time after

V 3

death, by drying; but in the natural course of events they all return to the state of simple elements; a wise and admirable dispensation of Providence, by which dead plants are rendered fit to enrich the soil, and become subservient to the nourishment of living vegetables.

Caroline. But we are talking of the dissolution of plants, before we have examined them in their living state.

Mrs. B. That is true, my dear. But I wished to give you a general idea of the nature of vegetation before we entered into particulars. Besides, it is not so irrelevant as you suppose to talk of vegetables in their dead state, since we cannot analyse them without destroying life; and it is only by hastening to submit them to examination, immediately after they have ceased to live, that we can anticipate their natural decomposition. There are two kinds of analysis of which vegetables are susceptible; first, that which separates them into their immediate materials, such as sap, resin, mucilage, &c. 2dly, that which decomposes them into their primitive elements, as carbone, hydrogen, and oxygen.

Emily. Is there not a third kind of analysis of plants which consists in separating their various parts, as the stem, the leaves, and the several organs of the flower?

Mrs. B. That, my dear, is rather the department of the botanist: we shall consider these different parts of plants, only as the organs by which the various secretions or separations are performed; but we must first examine the nature of these secretions.

The *sap* may be considered as the principal material of vegetables, since it contains the ingredients that nourish every part of the plant. The basis of this juice, which the roots suck up from the soil is water; this holds in solution the various other ingredients required by the several parts of the plant, which are gradually secreted from the sap by the different organs appropriated to that purpose, as it passes through them in circulating through the plant.

Mucus or *mucilage*, is a vegetable substance, which like all the others, is secreted from the sap; when in excess, it exudes from trees in the form of gum.

ne. Is that the gum so frequently used instead or glue?

B. It is; almost all fruit-trees yield some sort but that most commonly used in the arts is ob- om a species of acacia-tree in Arabia, and is *um Arabic*: it forms the chief nourishment of es of those parts, who obtain it in great quan- m incisions which they make in the trees.

ne. I did not know that gum was eatable.

B. I should not imagine that it would be eith- sant or a particularly elegible diet to those who t, from their birth, been accustomed to it. It ver, frequently taken medicinally, and consid- very nourishing. Several kinds of vegetable ay be obtained, by particular processes, from mucilage, the principal of which is called the *cid*:

r is not found in its simple state in plants, but is mixed with gum, sap, or other ingredients; it found in every vegetable, but abounds most in uits, and particularly in the sugar-cane.

y. If all vegetables contain sugar, why is it ex- exclusively from the sugar cane?

B. Because it it both most abundant in that nd most easily obtained from it.

ng the late troubles in the West-Indies, when was but imperfectly supplied with sugar, seve- mpts were made to extract it from other vege- and very good sugar was obtained from parsnips n carrots; but the process was too expensive this enterpize to any extent.

ine. I should think that sugar might be more obtained from sweet fruits, such as figs, dates,

B. Probably; but it would be still more ex- , from the high price of those fruits.

y. Pray in what manner is sugar obtained from ar-cane?

B. The juice of this plant is first expressed ing it between two cylinders of iron. It is then ith lime water, which makes a thick scum rise

to the surface. The clarified liquor is let off below and evaporated to a very small quantity, after which it is suffered to crystalize by standing in a vessel, the bottom of which is perforated with holes, that are imperfectly stopped, in order that the syrup may drain off. The sugar obtained by this process is a coarse brown powder, commonly called raw or moist sugar; it undergoes another operation to be refined and converted into loaf sugar. For this purpose it is dissolved in water, and afterwards purified by an animal fluid, called albumen. White of eggs chiefly consist of this fluid, which is also one of the constituent parts of blood; and consequently eggs, or bullock's blood, are commonly used for this purpose.

The albuminous fluid being diffused through the syrup, combines with all the solid impurities contained in it, and rises with them to the surface, where it forms a thick scum; the clear liquor is then again evaporated to a proper consistence, and poured into moulds, in which, by a confused chrystallization, it forms loaf sugar. But an additional process is required to whiten it; to this effect the mould is inverted, and its open base is covered with clay, through which water is made to pass; the water slowly trickling through the sugar combines with, and carries off the colouring matter.

Caroline. I am very glad to hear that the blood that is used to purify sugar does not remain in it, it would be a disgusting idea.

Emily. And pray how is sugar-candy and barley-sugar prepared?

Mrs. B. Candied sugar is nothing more than the regular crystals, obtained by slow evaporation from a solution of sugar. Barley sugar is sugar melted by heat, and afterwards cooled in moulds of a spiral form.

Sugar may be decomposed by a red heat; and, like all other vegetable substances, resolved into carbonic acid and hydrogen. The formation and the decomposition of sugar afford many very interesting particulars which we shall fully examine after having gone through the other materials of vegetables.—We shall find there is reason to suppose that sugar is not, like the other materials, secreted from the sap by appropriate organs,

t that it is formed by a peculiar process with which u are not yet acquainted.

Caroline. Pray is not honey of the same nature as gar?

Mrs. B. Honey is a mixture of sugar and gum.

Emily. I thought that honey was in some measure animal substance, as it is prepared by the bees.

Mrs. B. It is rather collected by them from flow-, and conveyed to their storehouses, the hives.— It he wax only that undergoes a real alteration in the ly of the bee, and is thence converted into an ani-l substance.

Emily. Cannot sugar be obtained from honey, since s so simple a compound?

Mrs. B. No mode has yet been discovered to ef-t this: it is supposed, however, to have been done the ancients, who were unacquainted with the sugar e, but the process is now unknown.

Manna is a compound of sugar, gum, and a nau-us extractive matter, to which last it owes its pe-iar taste and colour. It exudes like gum from vari-s trees in hot climates, some of which have their ves glazed by it.

The next of the vegetable materials is *fecula*; this is general name given to the farinaceous substance tained in all seeds, and in some roots, as the potato, snip, &c. It is intended by nature for the first ali-nt of the young vegetable; but that of one particular in is become a favourite and most common food of rge part of mankind.

Emily. You allude, I suppose, to bread, which is cle of wheat-flour?

Mrs. B. Yes. The fecula of wheat contains also other vegetable substance which seems peculiar to t seed, or at least has not as yet been obtained from y other. This is *gluten*, which is of a sticky, ropy, stic nature; and it is supposed to be owing to the ious qualities of this substance, that wheat flour ms a much better paste than any other.

Emily. Gluten, by your description, must be very e gum.

ly mentioned. Do you remember in
ence between fixed and volatile oil con

Emily. If I recollect right, the forn
posed by heat, whilst the latter are n
by it.

Mrs. B. Very well. Fixed oil is
in the seeds of plants, excepting in the
it is produced, and expressed from
have already observed that seeds con
these two substances, united with a little
the white substance contained in the s
of plants, and is destined for the nou
young plant, to which the seed gives b
of almonds, which is expressed from
name, is composed of these three subs

Emily. Pray of what nature is the l
is used in painting?

Mrs. B. It is a fixed oil obtained fr
flax. Nut oil, which is frequently us
purpose is expressed from walnuts.

Olive oil is that which is best adapted
poses.

cessary for the best constructed lamps to be occa-ally trimmed. This defect arises from a portion ucilage which it is extremely difficult to separate n the oil, and which being a bad combustible, ga-s round the wick, and thus impedes its combustion, consequently dims the light.

aroline. But will not oils burn without a wick ?

Mrs. B. Not unless their temperature be elevated 00° ; the wick answers this purpose, as I think I e before explained to you. The oil rises between fibres of the cotton by capillary attraction, and the of the burning wick volatilizes it, and brings it essively to the temperature at which it is combus-

mily. I suppose the explanation which you have n with regard to the necessity of trimming lamps, ies also to candles which so often require snuffing ?

Mrs. B. I believe it does; at least in some degree. Beside the circumstance just explained, the com-sort of oils are not very combustible, so that the produced by a candle, which is a coarse kind of al oil, being insufficient to volatilize them com-ly, a quantity of soot is gradually deposited on the , which dims the light and retards the combustion.

aroline. Wax candles then contain no incombusti-matter, since they do not require snuffing ?

Mrs. B. Wax is a much better combustible than w, but still not perfectly so, since it likewise con-s some particles that are unfit for burning ; but n these gather round the wick (which in a wax t is comparatively small) they weigh it down on side, and fall off together with the burnt part of wick.

aroline. As oils are such good combustibles, I won-that they should require so great an elevation of perature before they begin to burn.

Mrs. B. Though fixed oils will not enter into actual bustion below the temperature of about 400°, yet will slowly absorb oxygen at the common tempe-re of the atmosphere. Hence arises a variety of nges in oils which modify their properties and uses he arts.

In this case the alteration of the oil c
the addition of a certain quantity of
diminution of the hydrogen. The
guished by the name of *drying oils.*
and nut-oils are of this descripiton.

Emily. I am well acquainted wit
continually use them in painting. B
stand why the acquisition of oxygen
loss of hydrogen on the other, shoul
ing?

Mrs. B. This I conceive, may ar
sons; either from the oxygen which
favourable to the state of fluidity th
which is subtracted; or from this ad
oxygen giving rise to new combinatio
of which the most fluid parts of the oi
volatilized.

For the purpose of painting, the dr
is farther increased by adding a quan
to it, by which means it is more rapi
The rancidity of oils is likewise o
genation. In this case a new order
place, from which a peculiar acid is f

≈ess, from the action of oxygenated muriatic acid on hydro-carbonate.

Ve now pass to the *volatile* or *essential oils*. These the basis of all the vegetable perfumes, and are tained, more or less, in every part of the plant ex-ting the seed; they are, at least, never found in part of the seed which contains the embrio plant.

Emily. The smell of flowers then, proceeds from tile oil?

Mrs. B. Certainly; but this oil is often most abun-t in the rind of fruits, as in oranges, lemons, &c. n which it may be extracted by the slightest pres-e; it is found also in the leaves of plants, and even the wood.

Caroline. Is it not very plentiful in the leaves of at, and of thyme, and all the sweet-smelling herbs?

Mrs. B. Yes, remarkably so; and in geranium ves also, which have a much more powerful odour n the flowers.

The perfume of sandal fans is an instance of its ex-ence in wood. In short, all vegetable odours, or per-nes, are produced by the evaporation of particles of se volatile oils.

Emily. They are, I suppose, very light, and of very n consistence, since they are so volatile?

Mrs. B. They vary very much in this respect, some them being as thick as butter, whilst others are as id as water. In order to be prepared for perfumes, essences, these oils are first properly purified, and n either distilled with alcohol, as is the case with lav-ler water, or simply mixed with a large proportion water, as is often done with regard to peppermint. quently also, these odoriferous waters are prepared rely by soaking the plants in water, and distilling. e water then comes over impregnated with the vola-oil.

Caroline. Such waters are frequently used to take ts of grease out of cloth, or silk; how do they pro-ce that effect?

Mrs. B. By combining with the substance that ms these stains; for volatile oils dissolve wax, tallow,

spermaceti, and resins; if therefore the spot proce from any of these substances it will remove it.

Insects of all kinds have a great aversion to fumes; so that volatile oils are employed with suc in museums for the preservation of stuffed birds other species of animals.

Caroline. Pray does not the powerful smell of phor proceed from a volatile oil?

Mrs. B. Camphor seems to be a substance own kind, remarkable by many peculiarities. not exactly of the same nature as volatile oil, least very analogous to it. It is obtained chiefly the camphor tree, a species of laurel which gr China, and the Indian isles, from the stem and which it is extracted. Small quantities have als distilled from thyme, sage, and other aromatic and it is deposited in pretty large quantities by volatile oils after long standing. It is extreme tile and inflammable. It is insoluble in water, soluble in oils, in which state, as well as in it form, it is frequently applied to medicinal pu Amongst the particular properties of camphor is one too singular to be passed over in silence. take a small piece of camphor, and place it on t face of a bason of pure water, it will immediatel to move round and round with great rapidity; bu pour into the bason a single drop of any odorifer id, it will instantly put a stop to this motion. at any time try this very simple experiment; must not expect that I shall be able to account phenomenon, as nothing satisfactory has yet b vanced for its explanation.

Caroline. It is very singular indeed; and I tainly try the experiment. Pray what are *resins* you just now mentioned?

Mrs. B. They are volatile oils, that have be ed on, and peculiarly modified, by oxygen.

Caroline. They are, therefore, oxygenated oils.

Mrs. B. Not exactly; for the process does pear to consist so much in the oxygenation of as in the combustion of a portion of its hydro

all portion of its carbone. For when resins are cially made by the combination of volatile oils with gen, the vessel in which the process is performed edewed with water, and the air included within is ed with carbonic acid.

mily. This process must be, in some respects sim- to that for preparing drying oils.

Irs. B. Yes; and it is by this operation that both nem acquire a greater degree of consistence. Pitch, and turpentine, are the most common resins; they de from the pine and fir trees. Copal, mastic, and kincense, are also of this class of vegetable sub- ces.

Emily. Is it of these resins that the mastic and co- varnishes, so much used in painting, are made?

Irs. B. Yes. Dissolved either in oil or in alcohol, ns form varnishes. From these solutions they may precipitated by water, in which they are insoluble, s I can easily shew you. If you will pour some er into this glass of mastic varnish, it will combine n the alcohol in which the resin is dissolved, and latter will be precipitated in the form of a white ud—

Emily. It is so. And yet how is it that pictures or wings, varnished with this solution, may safely be hed with water.

Mrs. B. As the varnish dries, the alcohol evapo- es, and the dry varnish or resin which remains, not ng soluble in water, will not be acted on by it.

There is a class of compound resins called *gum re- s*, which are precisely what their name denotes, that o say, resins combined with mucilage. Myrrh and afœtida are of this description.

Caroline. Is it possible that a substance of so disa- eeable a smell as assafœtida can be formed from a atile oil?

Mrs. B. The odour of volatile oils is by no means vays grateful. Onions and garlic derive their smell m volatile oils, as well as roses and lavender.

There is still another form under which volatile oils esent themselves, which is that of *balsams*.—These

consist of resinous juices combined with a peculia
called the benzoic acid. Balsams appear to hav
originally volatile oils, the oxygenation of whi
converted one part into a resin and the other p
an acid, which, combined together, form a b
such are the balsams of Peru, Tolu, &c.

We shall now take leave of the oils and their
modifications, and proceed to the next vegetab
stance, which is *caoutchouc*. This is a white
glutinous fluid, which acquires consistence, and
ens in drying, in which state it forms the su
with which you are so well acquainted, under th
of gum-elastic.

Caroline. I am surprised to hear that gur
was ever white, or ever fluid ! And from what
ble is it procured ?

Mrs. B. It is obtained from two or three
species of trees in the East Indies, and South
ca, by making incisions in the stem. The jui
lected as it trickles from these incisions, and n
clay, in the form of little bottles of gum-ela
dipped into it. A layer of this juice adher
clay and dries on it ; and several layers are su
ly added by repeating this till the bottle is of
thickness. It is then beaten to break down t
which is easily shaken out.—The natives of t
tries where this substance is produced, so
make shoes and boots of it by a similar pro
they are said to be extremely pleasant and se
both from their elasticity, and from their bein
proof.

The substance which comes next in our enu
of the immediate ingredients of vegetables,
tive matter. This is a term, which, in a gene
may be applied to any substance extracted fr
tables ; but it is more particularly understood
to the extractive *colouring matter* of plants.
variety of colours are prepared from the
kingdom, both for the purposes of painting a
ing ; all the colours called *lakes* are of this
tion : but they are less durable than minera

by long exposure to the atmosphere, they either en or turn yellow.

nily. I know that in painting the lakes are reck- far less durable colours than the ochres ; but what reason of it?

rs. B. The change which takes place in vegeta- colours is owing chiefly to the oxygen of the at- here slowly burning their hydrogen, and leaving me measure the blackness of the carbone expos- Such a change cannot take place in ochre which ogether a mineral substance.

egetable colours have a stronger affinity for animal for vegetable substances, and this is supposed to wing to a small quantity of nitrogen which they in. Thus, silk and worsted will take a much finer table dye than linen and cotton.

roline. Dyeing, then, is quite a chemical pro- ?

rs. B. Undoubtedly. The condition required to a good dye is, that the colouring matter should recipitated, or fixed, on the substance to be dyed, should form a compound not soluble in the liquids hich it will probably be exposed. Thus, for in- e, printed or dyed linens or cottons must be able sist the action of soap and water, to which they must ssarily be subject in washing; and woolens and should withstand the action of grease and acids, to h they may accidentally be exposed.

roline. But if linen and cotton have not a sufficient ity for colouring matter, how are they made to re- he action of washing, which they always do when are well printed?

rs. B. When the substance to be dyed has either finity for the colouring matter, or not sufficient er to retain it, the combination is effected, or gthened, by the intervention of a third substance, d a *mordant*, or basis. The mordant must have a g affinity both for the colouring matter and the tance to be dyed, by which means it causes them mbine and adhere together.

roline. And what are the substances that perform

Emily. Is that the substance com
which is used in hot-houses?

Mrs. B. Tan is the prepared bark
culiar substance, tannin, is contained.
tan in hot-houses is of much less impo
operation of *tanning*, by which skin
leather.

Emily. Pray, how is this operation

Mrs. B. Various methods are en
purpose, which all consist in exposing
of the tannin, or of substances conta
ple, in sufficient quantities and dispose
skin. The most usual way is to infu
dered oak bark in water, and to keep
sed in this infusion for a certain lengt
ing this process, which is slow and gr
found to have increased in weight, and
a considerable tenacity and imperme
This effect may be much accelerated
saturations of the tanning principle (w
tracted from bark), instead of emplo
self. But this quick mode of prepara
pear to make equally good leather

melted isinglass into a glass of wine, which you
contains tannin?

rs. B. Yes. I have prepared a solution of isin-
for that very purpose.—Do you observe the thick
dy precipitate?—That is the tannin combined with
singlass.

roline. This precipitate must then be of the same
re as leather?

rs. B. It is composed of the same ingredients; but
organization and the texture of the skin being wan-
it has neither the consistence nor the tenacity of
ner.

roline. One might suppose that men who drink
e quantities of red wine, stand a chance of having
coats of their stomachs converted into leather, since
in has so strong an affinity for skin.

rs. B. It is not impossible but that the coats of
stomachs may be, in some measure, tanned, or
ened by the constant use of this liquor; but you
t remember that where a number of other chemi-
agents are concerned, and, above all, where life
ts, no certain chemical inference can be drawn.
must not dismiss this subject, without mentioning
ry recent discovery of Mr. Hatchett which relates
. This gentleman found that a substance very sim-
to tannin, possessing all its leading properties, and
ally capable of tanning leather, may be produced
exposing carbone, or any substance containing car-
aceous matter, whether vegetable, animal, or min-
, to the action of nitric acid.

aroline. And is not this discovery very likely to be
reat use to manufactures?

Mrs. B. That is very doubtful; because tannin,
s artificially prepared, must probably always be more
ensive than that which is obtained from bark. But
fact is extremely curious, as it affords one of those
rare instances of chemistry being able to imitate
proximate principles of organized bodies.

The last of the vegetable materials is *woody fibre*;
the hardest part of plants. The chief source from
ch this substance is derived is wood, but it is also

remains, more or less, in every solid part of the plant; it forms a kind of skeleton of the part to which it belonged, and retains its shape after all the other materials have disappeared. It consists chiefly of carbon united with a small proportion of salts and the other constituents common to all vegetables.

Emily. It is of woody fibre, then, that the common charcoal is made?

Mrs. B. Yes. Charcoal, as you may recollect, is obtained from wood by the separation of all its evaporable parts.

Before we take leave of the vegetable materials, I will endeavour, at least, to enumerate the several vegetable acids which we either have had, or may have occasion to mention. I believe I have formerly told you that their basis, or radical, was uniformly composed of hydrogen and carbone, and that their difference consisted only in the various proportions of oxygen which they contained.

The following are the names of the vegetable acids:

The *Mucous acid*, obtained from gum, or mucilage;
Suberic - - from cork;
Camphoric - - - from champhor;
Benzoic - - - - from balsams;
Gallic - - - - from galls, bark, &c.
Malic - - - - from ripe fruits;
Citric - - - - from lemon juice;
Oxalic - - - - from sorrel;
Succinic - - - - from amber;
Tartarous - - - from tartrit of potash
Acetous - - - - from vinegar.

These are all decomposable by heat, soluble in water, and turn vegetable blue colours red. The *succinic*, the [illegible], and the *acetous acids*, are the products of the decomposition of vegetables; we shall, therefore, reserve their examination for a future period.

The oxalic acid, distilled from sorrel, is the highest term of vegetable acidification; for, if more oxygen be added to it, it loses its vegetable nature, and is resolved into carbonic acid and water; therefore, the all the other acids may be converted into the oxali

ddition of oxygen, the oxalic itself is not suscepti-
of a farther degree of oxygenation; nor can it be
e, by any chemical process, to return to a state of
er acidification.

To conclude this subject, I have only to add a few
ds on the *gallic acid* . . . .

Caroline. Is not this the same acid before mention-
which forms ink, by precipitating sulphat of iron
n its solution?

Mrs. B. Yes. Though it is usually extracted from
s, on account of its being most abundant in that ve-
able substance, it may also be obtained from a great
ety of plants. It constitutes what is called the *as-
gent principle* of vegetables; it is generally combi-
with tannin, and you will find that an infusion of
coffee, bark, red wine, or any vegetable substance
contains the astringent principle, will make a black
cipitate with a solution of sulphat of iron.

Caroline. But pray what are galls?

Mrs. B. They are excrescences which grow on the
of young oaks, and are occasioned by an insect
ch wounds the bark of trees, and lays its egg in the
ture. The lacerated vessels of the tree then dis-
rge their contents, and form an excrescence which
ds a defensive covering for these eggs. The insect,
n come to life, first feeds on this excrescence,
some time afterwards eats its way out, as it ap-
s from a hole found in all gall-nuts that no longer
ain an insect. It is in hot climates only that strong-
stringent gall-nuts are found; those which are used
he purpose of making ink are brought from Alep-

Emily. But are not the oak-apples which grow on
leaves of the oak in this country, of a similar na-
e?

Mrs. B. Yes; only they are an inferior species of
ls, containing less of the astringent principle, and
refore less applicable to useful purposes.

Caroline. Are the vegetable acids never found but
their pure uncombined state?

Mrs. B. By no means; on the contrary, they are

frequently met with in the state of compound these, however, are in general not fully saturate the salifiable bases, so that the acid predominate in this state they are called *acidulous* salts. Of th is the salt called cream of tartar.

Caroline. Is not the salt of lemon commonl to take out ink spots and stains, of this nature?

Mrs. B. No; that salt consists merely of th acid reduced to the state of crystals.

Caroline. And pray how does it take out ink

Mrs. B. By decomposing the black precipit rendering it soluble in water. But the displa tractions by which this is performed is, I belie exactly ascertained.

Besides the vegetable materials which we ha merated, a variety of other substances, commo three kingdoms, are found in vegetables, such ash, which was formerly supposed to belong ex ly to plants, and was in consequence called the ble alkali.

Sulphur, phosphorus, earths, and a variety tallic oxyds, are also found in vegetables, but small quantities. And we meet sometimes w tral salts formed by the combination of these ents.

Conversation XVIII.

On the decomposition of Vegetables.

Caroline.

THE account which you have given us, M the materials of vegetables, is doubtless, ver

; but it does not completely satisfy my curiosity.— sh to know how plants obtain the principles from h their various materials are formed; by what ns these are converted into vegetable matter, and they are connected with the life of the plant?

Irs. B. This implies nothing less than a complete ry of the chemistry and physiology of vegetation, ects on which we have yet but very imperfect no-. Still I hope that I shall be able, in some mea-, to satisfy your curiosity. But in order to render ubject more intelligible, I must first make you ac-nted with the various changes which vegetables ergo, when the vital power no longer enables them esist the common laws of chemical attraction.

he composition of vegetables being more compli-d than that of minerals, the former more readily ergo chemical changes than the latter: for the ter the variety of attractions, the more easily is the librium destroyed, and a new order of combinations oduced.

mily. I am surprised that vegetables should be so y suceptible of decomposition; for the preserva-of the vegetable kingdom is certainly far more im-nt than that of minerals.

rs. B. You must consider, on the other hand, much more easily the former is renewed than the . The decomposition of the vegetable takes place after the death of the plant, which, in the com-course of nature, happens when it has yielded fruit eeds to propagate its species. If instead of thus ing its career, each plant was to retain its form vegetable state, it would become an uesless bur-to the earth and its inhabitants.—When vegeta-therefore, cease to be productive, they cease to and Nature then begins her process of decompo-, in order to dissolve them into their chemical ituents, hydrogen, carbone, and oxygen; those le and primitive ingredients which she keeps in for all her combinations.

ily. But since no system of combination can be oyed, *except by the* establishment of another or-

der of attractions, how can the decomposition ables reduce them to their simple elements?

Mrs. B. It is a very long process, duri a variety of new combinations are successi blished and successively destroyed; but, i these changes, the ingredients of vegetab tend to unite in a more simple order of comp they are at length brought to their elemen or at least, to their most simple order of co Thus you will find that vegetables are in most entirely reduced to water and carbonic hydrogen and carbone dividing the oxyge them, so as to form with it these two substa the variety of intermediate combinations that during the several stages of the decomposi getables, present us with a new set of comp worthy of our examination.

Caroline. How is it possible that vegeta putrefying, should produce any thing worth vation?

Mrs. B. They are susceptible of unde tain changes before they arrive at the state tion, which is the final term of decompositi these changes we avail ourselves for particu portant purposes. But, in order to make stand this subject, which is of considerable I must explain it more in detail.

The decomposition of vegetables is alwa by a violent internal motion, produced by t of one order of particles, and the combina ther. This is called *fermentation*.—There periods at which fermentation stops, so th rest appears to be restored, and the new or pounds fairly established. But, unless me to secure these new combinations in their their duration will be but transient, and a n tation will take place, by which the con formed will be destroyed; and another, an plex order will succeed.

Emily. The fermentation, then, appear the successive steps by which a vegetable its final dissolution.

rs. B. Precisely so. Your definition is perfectly ct.

roline. And how many fermentations, or new ar- ements, does a vegetable undergo before it is re- d to its simple ingredients?

rs. B. Chemists do not exactly agree in this point; there are, I think, four distinct fermentations, or ds, at which the decomposition of vegetable mat- tops and changes its course. But every kind of table matter is not equally susceptible of undergo- ll these fermentations.

here are likewise several circumstances required oduce fermentation. Water, and a certain de- of heat are both essential to this process, in order parate the particles, and thus weaken their force ohesion, that the new chemical affinities may be ght into action.

roline. In frozen climates, then, how can the spon- ous decomposition of vegetables take place?

rs. B. It certainly cannot; and, accordingly, we scarcely any vestiges of vegetation where a constant prevails.

aroline. One would imagine that, on the contrary, spots would be covered with vegetables; for, since cannot be decomposed, their numbers must always ease.

rs. B. But, my dear, heat and water are quite as ntial to the formation of vegetables as they are to r decomposition. Besides, it is from the dead ve- bles reduced to their elementary principles, that rising generation is supplied with sustenance. No ng plant, therefore, can grow, unless its predeces- contribute both to its formation and support; and se not only furnish the seed from which the new nt springs, but likewise the food by which it is nour- ed.

aroline. Under the torrid zone, therefore, where er is never frozen, and the heat is very great, both processes of vegetation and fermentation must, I pose, be extremely rapid?

Mrs. B. Not so much as you imagine; for climates great part of the water which is requi these processes is in an aeriform state, which is ly more conducive either to the growth or fo of vegetables than that of ice. In those latitudes, fore, it is only in low damp situations, shelt woods from the sun's rays, that the smaller vegetables can grow and thrive during the dry as dead vegetables seldom retain water enough duce fermentation, but are, on the contrary, so up by the heat of the sun, which enables them that process; so that it is not till the fall of the nal rains (which are very violent in such climat spontaneous fermentation can take place.

The several fermentations derive their nam their principal products. The first is called th *rine fermentation*, because its product is *sugar*.

Caroline. But sugar, you have told us, is all vegetables; it cannot, therefore, be the p their decomposition.

Mrs. B. It is true that this fermentation is fined to the decomposition of vegetables, as i ually takes place during their life; and indeed cumstance has, till lately prevented it from b sidered as one of the fermentations. But th appears so analogous to the other fermentat the formation of sugar, whether in living or de able matter, is so evidently a new compound, ing from the destruction of the previous order binations, and essential to the subsequent ferm that it is now esteemed the first step, or neces liminary, to decomposition, if not an actual co ment of that process.

Caroline. I recollect your hinting to us th was supposed not to be secreted from the sa same manner as mucilage, fecula, oil, and t ingredients of vegetables.

Mrs. B. It is rather from these materials, t the sap itself, that sugar is formed; and it is d at particular periods, as you may observe which become sweet in ripening, sometimes

y have been gathered. Life, therefore, is not es- tial to the formation of sugar, whilst, on the con- y, mucilage, fecula, and the other vegetable mate- s that are secreted from the sap by appropriate or- is, whose powers immediately depend on the vital ıciple, cannot be produced but during the existence hat principle.

Emily. The ripening of fruits is, then, their first to destruction, as well as their last towards perfec- ı?

Mrs. B. Exactly.—The saccharine fermentation juently takes place also during the cooking of veget- :s. This is the case with parsnips, carrots, pota- , &c. in which, sweetness is developed by heat and sture; and we know that if we carried the process tle farther, a more complete decomposition would ne. The same process takes place also in seeds vious to their sprouting.

Caroline. How do you reconcile this to your theory, s. B.? Can you suppose that a decomposition is the essary precursor of life?

Mrs. B. That is indeed the case. The materials the seed must be decomposed, and the seed dis- anized, before a plant can sprout from it.—Seeds, ides the embryo plant, contain (as we have already erved), fecula, oil, and a little mucilage. These stances are destined for the nourishment of the fu- e plant; but they must undergo some change be- e they can be fit for this function. The seeds, when ied in the earth, with a certain degree of moisture l of temperature, absorb water, which dilates them, arates their particles, and introduces a new order of actions, of which sugar is the product. The sub- ıce of the seed is thus softened, sweetened, and verted into a sort of white milky pulp, fit for the rishment of the embryo plant.

The saccharine fermentation of seeds is artificially luced, for the purpose of making *malt*, by the fol- ng process: A quantity of barley is first soaked in er for two or three days; the water being after- ds drained off, the grain heats spontaneously, swells,

bursts, sweetens, shews a disposition to germinate, and would actually sprout, if the process was not stopped by putting it into a kiln, where it is well dried at a gentle heat. In this state it is crisp and friable, and constitutes the substance called *malt*, which is the principal ingredient of beer.

Emily. But I hope you will tell us how malt is made into beer?

Mrs. B. Certainly; but I must first explain to you the nature of the second fermentation, which is essential to that operation. This is called the *vinous fermentation*, because its product is *wine*.

Emily. How very different the decomposition of vegetables is from what I had imagined. The products of their disorganization appear almost superior to those which they yield during their state of life and perfection.

Mrs. B. And do you not at the same time, admire the beautiful economy of Nature, which, whether she creates, or whether she destroys, directs all her operations to some useful and benevolent purpose? It appears that the saccharine fermentation is essential, as a previous step, to the vinous fermentation; so that if sugar be not developed during the life of the plant, the sacharine fermentation must be artificially produced before the vinous fermentation can take place. This is the case with barley, which does not yield any sugar until it is made into malt; and it is in that state only that it is susceptible of undergoing the vinous fermentation by which it is converted into beer.

Caroline. But if the product of the vinous fermentation is always wine, beer cannot have undergone that process; for beer is certainly not wine.

Mrs. B. Chemically speaking, beer may be considered as the wine of grain. For it is the product of the fermentation of malt, just as wine is that of the fermentation of grapes, or other fruits.

The consequence of the vinous fermentation is the decomposition of the saccharine matter, and the formation of a spirituous liquor from the constituents of the sugar. But, in order to promote this fermentation

only water and a certain degree of heat are necessa- but also some other vegetable ingredients, besides sugar, as fecula, mucilage, acids, salts, extractive :ter, &c. all of which seem to contribute to this cess.

Emily. It is, perhaps, for this reason, that wine is obtained from the fermentation of pure sugar; but : fruits are chosen for that purpose, as they contain only sugar, but likewise the other vegetable ingre- its which are requisite to promote the vinous fer- atation.

Mrs. B. Certainly. And you must observe also, : the relative quantity of sugar is not the only cir- istance to be considered in the choice of vegetable es for the formation of wine; otherwise the sugar- e would be best adapted for that purpose. It is ier the manner and proportion in which the sugar is ted with other vegetable ingredients that influences production and qualities of wine. And it is found : the juice of the grape not only yields the most siderable proportion of wine, but that it likewise rds it of the most grateful flavour.

Emily. I have seen a vintage in Switzerland, and I not recollect that heat was applied, or water added, roduce the fermentation of the grapes.

Mrs. B. The common temperature of the atmos- re, in the cellars in which the juice of the grape ermented, is sufficiently warm for this purpose; , as the juice contains an ample supply of water, e is no occasion for any addition of it.—But when nentation is produced in dry malt, a quantity of wa- must necessarily be added.

Emily. But what are precisely the changes that pen during the vinous fermentation?

Mrs. B. The sugar is decomposed, and its constitu- are recombined into two new substances; the one eculiar liquid substance, called *alcohol* or *spirit of* , which remains in the fluid; the other, carbonic gas, which escapes during the fermentation. Wine, efore, in a general point of view, may be consider s a liquid of which alcohol constitutes the essentia

part. And the varieties of strength and flavour of different kinds of wine are to be attributed to the ferent qualities of the fruits from which they are ol ed, independently of the sugar, without which no can be produced.

Caroline. I am astonished to hear that so pow a liquid as spirits of wine should be obtained fro mild a substance as sugar!

Mrs. B. Can you tell me in what the principa ference consists between alcohol and sugar?

Caroline. Let me reflect . . . . Sugar consi carbone, hydrogen, and oxygen. If carbonic ac subtracted from it, during the formation of al the latter will contain less carbone and oxygen th gar does; therefore hydrogen must be the pr ing principle of alcohol.

Mrs. B. It is exactly so. And this very larg portion of hydrogen accounts for the lightness and bustible property of alcohol, and of spirits in ge all of which consist of alcohol variously modified.

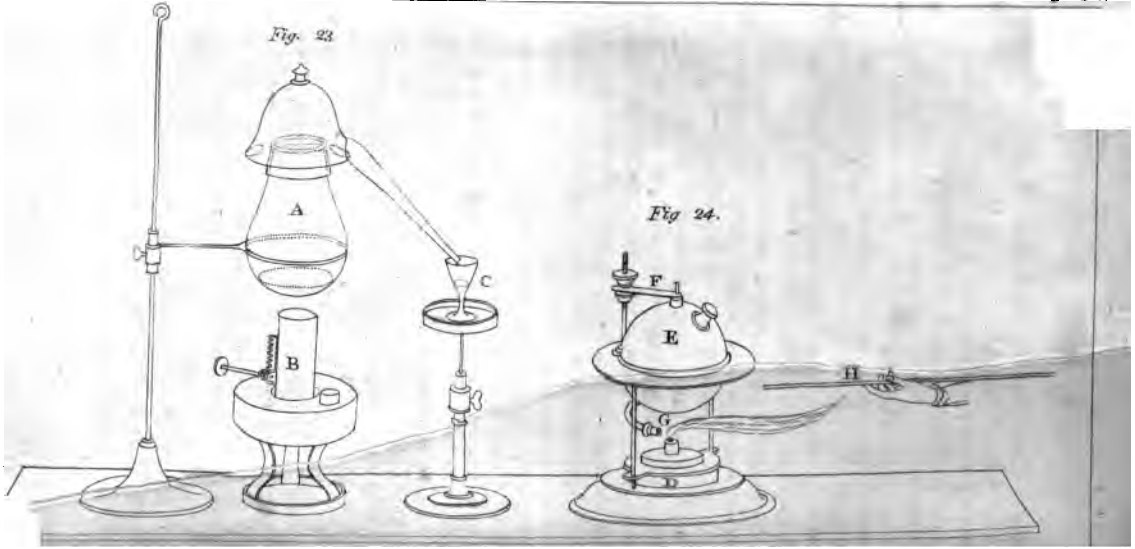
Emily. And can sugar be recomposed from the bination of alcohol and carbonic acid?

Mrs. B. Chemists have never been able to su in effecting this; but from analogy, I should su such a recomposition possible. Let us now c more particularly the phenomena that take plac ing the vinous fermentation. At the commenc of this process, heat is evolved, and the liquor considerably from the formation of the carboni which is disengaged in such prodigious quantiti be often prejudicial to the vintagers. If the fer tion be stopped by putting the liquor into barre fore the whole of the carbonic acid is evolved, th is brisk, like Champagne, from the carbonic ac prisoned in it, and it tastes sweet like cider, fr sugar not being completely decomposed.

Emily. But I do not understand why heat sh evolved during this operation. For, as there is siderable formation of gas, in which a propor quantity of heat must become insensible, I have imagined that cold, rather than heat, wo been produced.

Fig. 23

Fig 24.



Mrs. B. It appears so on first consideration; but must recollect that fermentation is a complicated mical process; and that, during the decompositions recompositions attending it, a quantity of chemical t may be disengaged, sufficient both to develope gas, and to effect an increase of temperature.— en the fermentation is completed, the liquid cools subsides, the effervescence ceases, and the thick, et, sticky juice of the fruit is converted into a clear sparent spirituous liquor called wine.

Emily. How much I regret not having been acinted with the nature of the vinous fermentation, n I had an opportunity of seeing the process!

Mrs. B. You have an easy method of satisfying rself in that respect by observing the process of wing, which, in every essential circumstance, is ilar to that of making wine, and is really a very cus chemical operation.

Although I cannot perform the experiment of making wine, it will be easy to shew you the mode of anang it. This is done by distillation. When wine of kind is submitted to this operation, it is found to tain brandy, water, tartar, extractive colouring mat- and some vegetable acids. I have put a little port e into this glass alembic (*Plate X. Fig.* 23.) and on cing the lamp under it, you will soon see these prots successively come over—

Emily. But you do not mention alcohol amongst the ducts of the distillation of wine; and yet that is its st essential ingredient.

Mrs. B. The alcohol is contained in the brandy ich is now coming over, and dropping from the still. andy is nothing more than a mixture of alcohol and ter; and in order to obtain the alcohol pure, we st again distil it from brandy.

Caroline. I have just taken a drop on my finger;

PLATE X.

Fig. 23. A. Alembic. B. Lamp. C. Wine glass.
Fig. 24 Alcohol blow-pipe. D. The Lamp. E. The vesin which the alcohol is boiling. F. A safety valve. G. The amed jet or stream of alcohol directed towards a glass tube H.

it tastes like strong brandy, but it is withou
whilst brandy is of a deep yellow.

Mrs. B. It is not so naturally; in its pu
brandy is colourless, and it obtains the yellow
observe by extracting the colouring matter
new oaken casks in which it is kept.

But if it does not acquire the usual tinge this
the custom to colour the brandy used in thi
artificially, in order to give it the appearance
been long kept.

Caroline. And is rum also distilled from wi

Mrs. B. By no means; it is distilled from
gar-cane, a plant which contains so great a q
sugar, that it yields more alcohol than almost
vegetable. Previous to the distillation of the
sugar-cane is made to undergo the vinous ferm
which the other ingredients of the plant are
cient to promote.

The spirituous liquor called *arack*, is in
manner distilled from the product of the vinous
tation of rice.

Emily. But rice has no sweetness; does i
any sugar?

Mrs. B. Like barley and most other seeds
sipid until it has undergone the saccharine f
tion; and this, you must recollect, is always
ous step to the vinous fermentation in those v
in which sugar is not already formed. Brand
the same manner be obtained from malt.

Caroline. You mean from beer, I suppose
malt must have previously undergone the vi
mentation.

Mrs. B. Beer is not precisely the produ
vinous fermentation of malt. For hops are a
ingredient for the formation of that liquor; wh
dy is distilled from pure fermented malt. Bu
might, no doubt, be distilled from beer as wel
any other liquor that has undergone the vinous
tation; for since the basis of brandy is alcoho
be obtained from any liquid that contains that
ubstance.

Emily. And pray, from what vegetable is the favorite spirit of the lower orders of people, gin, extracted?

Mrs. B. The spirit (which is the same in all fermented liquors) may be obtained from any kind of grain; but the peculiar flavour which distinguishes gin, is that of juniper berries, which are distilled together with the grain—

I think the brandy contained in the wine which we are distilling, must, by this time, be all come over. Yes—taste the fluid that is now dropping from the alembic—

Caroline. It is perfectly insipid, like water.

Mrs. B. It is water, which, as I was telling you, is the second product of wine, and comes over after all the spirit, which is the lightest part, is distilled. The tartar and extractive colouring matter we shall find in a solid form at the bottom of the alembic.

Emily. they look very like the lees of wine.

Mrs. B. And in many respects they are of a similar nature; for lees of wine consist chiefly of tartrit of potash, a salt which exists in the juice of the grape, and in many other vegetables, and is developed only by the vinous fermentation. During this operation it is precipitated, and deposites itself on the internal surface of the cask in which the wine is contained. It is much used in medicine under the name of *cream of tartar*, and it is from this salt that the tartarous acid is obtained.

Caroline. But the medicinal cream of tartar is in appearance quite different from these dark coloured dregs; it is perfectly colourless.

Mrs. B. Because it consists of the pure salts only, in its crystallized form; whilst in the instance before us it is mixed with the deep-coloured extractive matter and other foreign ingredients.

Emily. Pray cannot we now obtain pure alcohol from the brandy which we have distilled?

Mrs. B. We might: but the process would be tedious: for in order to obtain alcohol perfectly free from water, it is necessary to distil, or as the distillers call it *rectify* it several times. You must therefore al-

low me to produce a bottle of alcohol that has been thus purified. This is a very important ingredient, which has many striking properties, besides its forming the basis of all spirituous liquors.

Emily. It is alcohol, I suppose, that produces intoxication?

Mrs. B. Certainly; but the stimulus and momentary energy it gives to the system, and the intoxication it occasions when taken in excess, are circumstances not yet accounted for.

Caroline. I thought that it produced these effects by increasing the rapidity of the circulation of the blood; for drinking wine or spirits, I have heard always quickens the pulse.

Mrs. B. No doubt; the spirit by stimulating the nerves, increases the action of the muscles; and the heart, which is one of the strongest muscular organs, beats with augmented vigour and propels the blood with accelerated quickness. After such strong excitation the frame naturally suffers a proportional degree of depression, so that a state of debility and languor are the invarible consequences of intoxication. But though these circumstances are well ascertained, they are far from explaining why alcohol should produce such effects.

Emily. Liqueurs are the only kind of spirits which I think pleasant. Pray of what do they consist?

Mrs. B. They are composed of alcohol, sweetened with syrup, and flavoured with volatile oil.

The different kinds of odoriferous spirituous waters are likewise solutions of volatile oil in alcohol, as lavender water, eau de Cologne, &c.

The chemical properties of alcohol are important and numerous. It is one of the most powerful chemical agents, and is particularly useful in dissolving a variety of substances which are soluble neither by water nor heat.

Emily. We have seen it dissolve copal and mastic to form varnishes; and these resins are certainly not soluble in water, since water precipitates them from their solution in alcohol.

Mrs. B. I am happy to find that you recollect these circumstances so well. The same experiment affords also an instance of another property of alcohol, its tendency to unite with water; for the resin is precipitated in consequence of losing the alcohol, which abandons it from its preference for water. We do not, however, consider the union of alcohol and water, as the effect of chemical combination, but rather as a simple solution, similar to that of sulphuric acid and water; it is attended also, as you may recollect, with the same peculiar circumstance of a disengagement of heat and consequent diminution of bulk, which we have supposed to be produced by a mechanical penetration of particles by which latent heat is forced out.

Alcohol unites thus readily not only with resins and with water, but with oils and balsams; these compounds form the extensive class of elixirs, tinctures, quintescences. &c.

Emily. I suppose that alcohol must be highly combustible, since it contains so large a proportion of hydrogen?

Mrs. B. Extremely so; and it will burn at a very moderate temperature.

Caroline. I have often seen both brandy and spirit of wine burnt; they produce a great deal of flame, but not a proportional quantity of heat, and no smoke whatever.

Mrs. B. The last circumstance arises from their combustion being complete; and the disproportion between the flame and heat shows you that these are by no means synonimous.

The great quantity of flame proceeds from the combustion of the hydrogen, to which, you know, that manner of burning is peculiar.—Have you not remarked also, that brandy and alcohol will burn without a wick? They take fire at so low a temperature, that this assistance is not required to concentrate the heat and volatilize the fluid.

Caroline. I have sometimes seen brandy burnt by merely heating it in a spoon.

Mrs. B. The rapidity of the combustion of alcohol

may, however, be prodigiously increased by volatilizing it. An ingenious instrument has been constructed on this principle to answer the purpose of a blow-pipe, which may be used for melting glass or other chemical purposes. It consists of a small metallic vessel (*Plate* X. *Fig.* 24.) of a spherical shape, which contains the alcohol, and is heated by the lamp beneath it; as soon as the alcohol is volatilized, it passes through the spout of the vessel, and issues just above the wick of the lamp, which immediately sets fire to the stream of vapour, as I shall shew you—

Emily. With what amazing violence it burns! The flame of alcohol in the state of vapour, is, I fancy, much hotter than when the spirit is merely burnt in a spoon?

Mrs. B. Yes; because in this way the combustion goes on much quicker, and, of course, the heat is proportionally increased.—Observe its effect on this small glass tube, the middle of which I present to the extremity of the flame, where the heat is greatest.

Caroline. The glass, in that spot, is become red hot, and bends from its own weight.

Mrs. B. I have now drawn it asunder, and am going to blow a ball at one of the heated ends; but I must previously close it up, and flatten it with a little metallic instrument, otherwise the breath would pass through the tube without dilating any part of it. Now, Caroline, will you blow strongly into the tube whilst the closed end is red hot?

Emily. You blowed too hard; for the ball suddenly dilated to a great size, and then burst in pieces.

Mrs. B. You will be more expert another time; but I must caution you, should you ever use this blow-pipe, to be very careful that the combustion of the alcohol does not go on with too great violence, for I have seen the flame sometimes dart out with such force as to reach the opposite wall of the room, and set the paint on fire. There is, however, no danger of the vessel bursting, as it is provided with a safety tube, which affords an additional vent for the vapour of alcohol when required.

The products of the combustion of alcohol consist in

a great proportion of water, and a small quantity of carbonic acid. There is no smoke or fixed remains whatever. How do you account for that, Emily?

Emily. I suppose that the oxygen which the alcohol absorbs in burning, converts its hydrogen into water, and its carbone into carbonic acid gas; and thus it is completely consumed.

Mrs. B. Very well.—*Ether*, the lighest of all fluids, and with which you are well acquainted, is obtained from alcohol, of which it forms the lightest and most volatile part.

Emily. Ether, then, is to alcohol, what alcohol is to brandy?

Mrs. B. No: there is an essential difference. In order to obtain alcohol from brandy, you need only deprive the latter of its water; but for the formation of ether, the alcohol must be decomposed, and one of its constituents partly subtracted. I leave you to guess which of them it is—

Emily. It cannot be hydrogen, as ether is more volatile than alcohol, and hydrogen is the lightest of all its ingredients: nor do I suppose that it can be oxygen, as alcohol contains so small a proportion of that principle; it is therefore, most probably carbone, a diminution of which would not fail to render the new compound more volatile.

Mrs. B. You are perfectly right. The formation of ether consists simply in subtracting from the alcohol a certain proportion of carbone; this is effected by the action of the sulphuric, nitric, or muriatic acids on alcohol. The acid and carbone remain at the bottom of the vessel, whilst the decarbonized alcohol flies off in the form of a condensable vapour, which is ether.

Ether is the most inflamable of all fluids, and burns at so low a temperature that the heat evolved during its combustion is more than is required for its support, so that a quantity of ether is volatilized, which takes fire, and gradually increases the violence of the combustion.

This spirituous fluid is so light that it evaporates at the common temperature of the atmosphere, it is there-

fore necessary to keep it confined by a well ground glass stopper. No degree of cold known has ever frozen it.

Caroline. Is it not often taken medicinally?

Mrs. B. Yes; it is one of the most effectual antispasmodic medicines, and the quickness of its effects, as such, probably depends on its being instantly converted into vapour by the heat of the stomach, through the intervention of which it acts on the nervous system. But the frequent use of ether, like that of spirituous liquors, becomes prejudicial, and, if taken to excess, it produces effects similar to those of intoxication.

We may now take our leave of the vinous fermentation, of which I hope, you have acquired a clear idea; as well as of the several products that are derived from it.

Caroline. Though this process appears at first sight so much complicated, it may, I think, be summed up in few words, as it consists simply in the conversion of sugar into alcohol and carbonic-acid, which gives rise both to the formation of wine, and of all kinds of spirituous liquors.

Mrs. B. We shall now proceed to the *acetous fermentation*, which is thus called, because it converts wine into vinegar, by the formation of the acetous acid, which is the basis or radical of vinegar.

Caroline. But is not the acidifying principle of the acetous acid the same as that of all other acids, oxygen?

Mrs. B. Certainly; and on that account the contact of air is essential to this fermentation, as it affords the necessary supply of oxygen. Vinegar, in order to obtain pure acetous acid from it, must be distilled and rectified by certain processes; and the more frequently this operation is repeated, the more perfect the acid will be.

Emily. But pray, Mrs B. is not the acetous acid frequently formed without this fermentation taking place? Is it not, for instance, contained in acid fruits, and in every substance that becomes sour?

Mrs. B. No, not in fruits; you confound it with the citric, the malic, the oxalic, and other vegetable

acids, to which living vegetables owe their acidity. But whenever a vegetable substance turns sour, after it has ceased to live, the acetous acid is developed by means of the acetous fermentation, in which the substance advances a step towards its final decomposition.

Amongst the various instances of acetous fermentation, that of bread is usually classed.

Caroline. But the fermentation of bread is produced by yeast; how does that effect it?

Mrs. B. It is found by experience that any substance that has already undergone a fermentation, will readily excite it in one that is susceptible of that process. If, for instance, you mix a little vinegar with wine that is intended to be acidified, it will absorb oxygen more rapidly, and the process be completed much sooner that if left to ferment spontaneously. Thus, yeast, which is a product of the fermentation of beer, is used to excite and accelerate the fermentation of malt, which is to be converted into beer, as well as that of paste that is to be made into bread.

Caroline. But if bread undergoes the acetous fermentation, why is it not sour?

Mrs. B. It acquires a certain savour which corrects the heavy insipidity of flour, and may be reckoned a first degree of acidification; for if the process was carried farther, the bread would become decidedly acid.

There are, however, some chemists who do not consider the fermentation of bread as being of the acetous kind, but suppose that it is a process of fermentation peculiar to that substance.

The *putrid fermentation* is the final operation of Nature, and her last step towards reducing organized bodies to their simplest combinations. All vegetables spontaneously undergo this fermentation after death, provided there be a sufficient degree of heat and moisture, together with access of air; for it is well known that dead plants may be preserved by drying, or by the total exclusion of air.

Caroline. But do dead plants undergo the other fermentations previous to this last; or do they immediately suffer the putrid fermentation?

Mrs. B. That depends on a variety of circumstances, such as the degrees of temperature and of moisture, the nature of the plant itself, &c. But, if you were carefully to follow and examine the decomposition of plants from their death to their final dissolution, you would generally find a sweetness developed in the seeds, and a spirituous flavour in the fruits, (which have undergone the saccharine fermentation), previous to the total disorganization and separation of the parts.

Emily. I have sometimes remarked a kind of spirituous taste in fruits that were over ripe, especially oranges; and this was just before they became rotten.

Mrs. B. It was then the vinous fermentation which had succeeded the saccarine, and had you followed up these changes attentively, you would probably have found the spirituous taste followed by acidity, previous to the fruit passing to the state of putrefaction.

When the leaves fall from the trees in autumn, they do not (if there is no great moisture in the atmosphere) immediately undergo a decomposition, but are first dried and withered; as soon, however, as the rain sets in, fermentation commences, their gaseous products are imperceptibly evolved into the atmosphere, and their fixed remains mixed with their kindred earth.

Wood, when exposed to moisture, also undergoes the putrid fermentation and becomes rotten.

Emily. But I have heard that the *dry rot*, which is so liable to destroy the beams of houses, is prevented by a current of air; and yet you said that air was essential to the putrid fermentation?

Mrs. B. True; but it must not be in such a proportion to the moisture as to dissolve the latter, and this is generally the case when the rotting of wood is prevented or stopped by the free access of air.—What is commonly dry rot, however, is not, I believe, a true process of putrefaction. It is supposed to depend on a peculiar kind of vegetation, which, by feeding on the wood, gradually destroys it.

Straw and all other kinds of vegetable matter undergo the putrid fermentation much more rapidly when mixed with animal matter. Much heat is evolved

ing this process, and a variety of volatile products are disengaged, as carbonic acid and hydrogen gas, the latter of which is frequently either sulphurated or phosphorated. When all these gasses have been evolved, the fixed products consisting of carbone, salts, potash, &c. form a kind of vegetable earth, which makes very fine manure, as it is composed of those elements which form the immediate materials of plants.

Caroline. Pray are not vegetables sometimes preserved from decomposition be petrifaction ? I have seen very curious specimens of petrified vegetables, in which state they perfectly preserve their form and organization, though in appearance they are changed to stone.

Mrs. B. That is a kind of metamorphosis, which, now that you are tolerably well versed in history of mineral and vegetable substances, I leave to your judgment to explain. Do you imagine that vegetables can be converted into stone ?

Emily. No certainly ; but they might perhaps be changed to a substance in appearance resembling stone.

Mrs. B. It is not so, however, with the substances that are called petrified vegetables ; for these are really stone, and generally of the hardest kind, consisting chiefly of silex. The case is this : when a vegetable is buried under water, or in wet earth, it is slowly and gradually decomposed. As each successive particle of the vegetable is destroyed, its place is supplied by a particle of silicious earth, conveyed thither by the water. In the course of time the vegetable is entirely destoyed, but the silex has completely replaced it, having assumed its form and apparent texture, as if the vegetable itself were changed to stone.

Caroline. That is very curious ! and I suppose that petrified animal substances are of the same nature ?

Mrs. B. Precisely. It is equally impossible for either animal or vegetable substances to be converted into stone. They may be reduced, as we find they are, by decomposition, to their constituent elements, but cannot be changed to elements, which do not enter into their composition.

There are, however, circumstances which frequently prevent the regular and final decomposition of vegetables; as, for instance, when they are buried either in the sea, or in the earth, where they cannot undergo the putrid fermentation for want of air. In these cases they are subject to a peculiar change, by which they are converted into a new class of compounds, called *bitumens*.

Caroline. These are substances I never heard of before.

Mrs. B. You will find, however, that some of them are very familiar to you. Bitumens are vegetables so far decomposed as to retain no organic appearance; but their origin is easily detected by their oily nature, their combustibility, the products of their analysis, and the impressions of the forms of leaves, grains fibres of wood, and even of animals, which they frequently bear.

They are sometimes of an oily liquid consistence, as the substance called *naphtha*, which is a fine transparent colourless fluid, that issues out of clays in some parts of Persia. But more frequently they are solid as *asphaltum*, a smooth hard brittle substance, which easily melts, and forms, in its liquid state, a beautiful dark brown colour for oil painting. *Jet*, which is of a still harder texture, is a peculiar *bitumen*, susceptible of so fine a polish that it is used for many ornamental purposes.

Coal is also a bituminous substance, to the composition of which both the mineral and animal kingdoms seem to concur. This most useful mineral appears to consist chiefly of vegetable matter, mixed with remains of marine animals and marine salts, and occasionally containing a quantity of sulphuret of iron, commonly called pyrites.

Emily. It is, I suppose, the earthy, the metallic, and the saline parts of coals, that compose the cinders or fixed products of their combustion; whilst the hydrogen and the carbone, which they derive from vegetables, constitute their volatile products.

Caroline. Pray is not *coak* (which I have heard is much used in some manufactures) also a bituminous substance?

Mrs. B. It is a kind of fuel artificially prepared from als. It consists of coals reduced to a substance anal-ous to charcoal, by the evaporation of their volatile rts. Coak, therefore, is composed of carbone, with me earthy and saline ingredients.

Succin, or *yellow amber*, is a bitumen which the an-nts called *electrum*, from whence the word electricity derived, as that substance is peculiarly, and was once pposed to be exclusively electric. It is found either eply buried in the bowels of the earth, or floating on e sea, and is supposed to be a resinous body which s been acted on by sulphuric acid, as its analysis ews it to consist of an oil and an acid. The oil is call- *oil of amber*, the acid the *succinic*.

Emily. That oil I have sometimes used in painting, it is reckoned to change less than the other kinds of ls.

Mrs. B. The last class of vegetable substances that ve changed their nature are *fossil wood*, *peat*, and rf. These are composed of wood and roots of shrubs, at are partly decomposed by being exposed to mois-re under ground, and yet, in some measure, preserve eir form and organic appearance. The peat, or black rth of the moors, retains but few vestiges of the roots which it owes its richness and combustibility, these bstances being in the course of time reduced to the ate of vegetable earth. But in turf the roots of plants e still discernable, and it equally answers the purpose f fuel. It is the combustible used by the poor in eathy countries, which supply it abundantly.

It is too late this morning to enter upon the history f vegetation. We shall reserve this subject, there-re, for our next interview, when I expect that it will urnish us with ample matter for another conversation.

Conversation XIX.

History of Vegetation.

Mrs. B.

The Vegetable Kingdom may be considered a link which unites the mineral and animal creatio one common chain of beings; for it is throug means of vegetation alone that mineral substanc introduced into the animal system, since gen speaking it is from vegetables that all animals ulti ly derive their sustenance.

Caroline. I do not understand that; the huma cies subsists as much on animal as on vegetable and there are some carnivorous animals that w only animal food.

Mrs. B. That is true; but you do not conside those that live on animal food derive their suste equally, though not so immediately, from veget The meat that we eat is formed from the herbs o field, and the prey of carnivorous animals pro either directly or indirectly, from the same sourc is therefore through this channel that the simpl ments become a part of the animal frame. We s in vain attempt to derive nourishment from ca hydrogen, and oxygen, either in their separate or combined in the mineral kingdom; for it is o being united in the form of vegetable combinatio they become capable of conveying nourishment.

Emily. Vegetation then, seems to be the m which nature employs to prepare the food of ani

Mrs. B. That is certainly its principal object.- vegetable creation does not exhibit more wisdom i admirable system of organization, by which it is led to answer its own immediate ends of preserva trition, and propagation, than in its grand and

ect of forming those arrangements and combina-
s of principles, which are so well adapted for the
rishment of animals.

Emily. But I am very curious to know whence veg-
les obtain those principles, which form their imme-
e materials?

Mrs. B. This is a point on which we are yet so
h in the dark, that I cannot hope fully to satisfy
r curiosity; but what little I know on this subject,
ll endeavour to explain to you.

The soil, which, at first view, appears to be the ali-
nt of vegetables, is found, on a closer investigation, to
ittle more than the channel through which they re-
e their nourishment; so that it is very possible to
plants without any earth or soil.

Caroline. Of that we have an instance in the hya-
h and other bulbous roots, which will grow and blos-
beautifully in glasses of water. But I confess I
uld think it would be difficult to rear trees in a simi-
manner.

Mrs. B. No doubt it would, as it is the burying of
roots in the earth that supports the stem of the tree.
t this office, besides that of affording a vehicle for
d, is far the most important part which the earthy
tions of the soil perform in the process of vegeta-
; for we can discover by analysis but an extremely
all proportion of earth in vegetable compounds.

Caroline. But if earths do not afford nourishment,
y is it necessary to be so attentive to the preparation
the soil?

Mrs. B. In order to impart to it those qualities
ich render it a proper vehicle for the food of the
nt. Water is the chief nourishment of vegetables;
therefore, the soil be too sandy, it will not retain a
antity of water sufficient to supply the roots of the
nts. If, on the contrary, it abounds too much with
y, the water will lodge in such quantities as to threa-
a decomposition of the roots.—Calcareous soils are
on the whole, the most favourable to the growth of
nts, from their containing in great abundance car-
ic acid, which is one of the most essential ingredi-

ents of vegetation. Soils are, there
proved by chalk, which you may r
bonat of lime. Different vegetables,
different kinds of soils. Thus rice
retentive soil; potatoes a soft sandy s
and rich soil. Forest trees grow bette
in a stiff clay; and a light feruginou
ted to fruit trees.

Caroline. But pray what is the use
soil?

Mrs. B. Manure consists of all ki
whether of vegetable or animal origin
dergone the putrid fermentation and
decomposed, or nearly so, into their
ciples. Now, I ask you what is the
ing the soil with these decomposed sul

Caroline. It is, I suppose, in orde
tables with the principles which ente
position. For manures not only con
drogen, and oxygen, but by their de
ply the soil with these principles in
form.

Mrs. B. Undoubtedly; and it is fo
the finest crops are produced in fields t
ly covered with woods, because their
of a rich mould, a kind of vegetabl
bounds in those principles.

Emily. This accounts for the ple
crops produced in America, where th
a few years since covered with wood.

Caroline. But how is it that anima
reckoned to produce the best manure
pear much more natural that the decor
of vegetables should be the most appro
mation of new vegetables?

Mrs. B. The addition of a much g
of nitrogen, which constitutes the chi
tween animal and vegetable matter, r
position of the former more complic
quently more favourable to decompo
of animal substances is chiefly to giv

: fermentation of the vegetable ingredients that en-
to the composition of manures. The manure of
n-yard is of that description; but there is scarcely
ubstance susceptible of undergoing the putrid fer-
ation that will not make good manure. The heat
ıced by the fermentation of manure is another
mstance which is extremely favourable to veget-
; yet this heat would be too great if the manure
aid on the ground in the height of fermentation;
ısed in this state only for hot-beds, to produce mel-
cucumbers, and such vegetables as require a very
temperature.

roline. A difficulty has just occurred to me which
not know how to remove.—Since all organized
:s are, in the common course of nature, ultimately
:ed to their elementary state, they must necessa-
n that state enrich the soil, and afford food for ve-
ion. How is it then that agriculture, which can-
ıcrease the quantity of those elements that are re-
:d to manure the earth, can increase its produce
›nderfully, as is found to be the case in all culti-
l countries?

rs. B. It is by suffering none of these principles
main inactive, and by employing them to the best
ıtage. This object is attained by a judicious pre-
ion of the soil, which consists in fitting it either
.e general purposes of vegetation, or for that of
articular seed which is to be sown. Thus, if the soil
› cold, it may be warmed by slakeing lime upon
too loose and sandy, it may be rendered more
stent and retentive of water by the addition of clay
ım; if too poor, it may be enriched by chalk or
ind of calcareous earth. On soils thus improved,
ıres will act with double efficacy, and if attention
.id to spread them on the ground at a proper sea-
f the year, to mix them with the soil so that they
be generally diffused through it, to destroy the
s that might apropriate these nutritive principles
eir own use, to remove the stones which would
de the growth of the plant, &c. we may obtain a
ıce an hundred fold more abundant than the earth
d spontaneously supply.

Emily. We have a very striking insta the scanty produce of uncultivated commo to the rich crops of meadows which are manured.

Caroline. But, Mrs. B. though exp proves the advantages of cultivation, there culty which I cannot get over. A certa elementary principles exist in nature, w in the power of man either to augmen Of these principles you have taught us th imal and vegetable creation are compos more of them is taken up by the vegeta the less, it would seem, will remain for therefore the more populous the earth less it will produce.

Mrs. B. Your reasoning is very plau perience every where contradicts the would draw from it: for we find that t vegetable kingdoms, instead of thriving suppose, at each other's expense, alway multiply together. Indeed, you must a conclusion would be valid only if every several principles that could possibly b other purposes were employed in the an table creations. Now we have reason a much greater proportion of these pri required for such purposes remains, ei mentary state, or engaged in a less u combination in the mineral kingdom. such immense resources as the atmos waters afford us, for oxygen, hydroger so far from being in danger of working ple materials, we cannot suppose that bring agriculture to such a degree of require the whole of what these resourc

Nature, however, in thus furnishing exhaustible stock of raw materials, lea measure to the ingenuity of man to ap to his own purposes. But, like a kind mules him to exertion, by setting th pointing out the way. For it is on th nature that all the improvements of art

: of agriculture consists, therefore, in discovering
liest method of obtaining the several principles,
om their grand sources, air and water, or from
omposition of organized bodies ; and in appropri-
em in the best manner to the purposes of vege-

/. But, among the sources of nutritive princi-
m surprised that you do not mention the earth
s it contains abundance of coals which are chief-
osed of carbone.

B. You must recollect that coals are, principal-
entirely, of vegetable origin ; and therefore, the
hould be considered rather as the vehicle thro'
lecayed organized matter is gradually brought
tate of coals, than as the original source of that
combustible. Besides, you know, that tho'
ound in carbone, they cannot on account of their
s and impermeable texture, be immediately
ient to the purposes of vegetation.

/. No; but by their combustion carbonic acid
ced ; and this entering into various combina-
the surface of the earth, may perhaps assist in
ng vegetation.

B. Prebably it may in some degree ; but at
the quantity of nourishment, which vegetables
rive from that source, can be but very trifling,
st entirely depend on local circumstances.

line. Porhaps the smoky atmosphere of Lon-
he reason why vegetation is so forward and so
its vicinity ?

B. I rather believe that this circumstance pro-
om the very ample supply of manure, assisted
by the warmth and shelter which the town af-
Far from attributing any good to the smoky at-
re of London, I confess, I like to anticipate
e when we shall have made such progress in
of managing combustion, that every particle of
will be consumed, and the smoke destroyed
noment of its production. We may then ex-
have the satisfaction of seeing the atmosphere
don as clear as that of the country.—But to re-

turn to our subject: I hope that you are now convinced that we shall not easily experience a deficiency of nutritive elements to fertilize the earth, and that, provided we are but industrious in applying them to the best advantage by improving the art of agriculture, no limits can be assigned to the fruits that we may expect to reap from our labours!

Caroline. Yes; I am perfectly satisfied in that respect, and can assure you that I feel already much more interested in the progress and improvement of agriculture.

Emily. I have often thought that the culture of the land was not considered as a concern of sufficient importance. Manufactures always take the lead; and health and innocence are frequently sacrificed to the prospect of a more profitable employment. It has often grieved me to see the poor manufacturers crowded together in close rooms, and confined for the whole day to the most uniform and sedantary employment, instead of being engaged in that innocent and salutary kind of labour, which nature seems to have assigned to man for the immediate acquirement of comfort, and for the preservation of his existence. I am sure that you agree with me in thinking so, Mrs. B?

Mrs. B. I am entirely of your opinion, my dear, in regard to the importance of agriculture; but I am far from wishing to depreciate manufactures; for as the labour of one man is sufficient to produce food for several, those whose industry is not required in tillage must do something in return for the food that is provided for them. They exchange, consequently, the accommodations for the necessaries of life. Thus the carpenter and the weaver lodge and clothe the peasant, who supplies them with their daily bread. The greater stock of provisions, therefore, which the husbandman produces, the greater is the quantity of accommodation which the artificer prepares. Such are the happy effects which naturally result from civilized society. It would be wiser, therefore, to endeavour to improve the situation of those who are engaged in manufactures, than to indulge in vain declamations on the hardships to which they are often exposed.

Apparatus to exemplify the mechanism of breathing

Germination

Fig. 5.

Fig. 26.

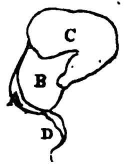
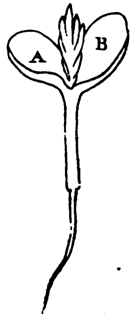


Fig. 27.



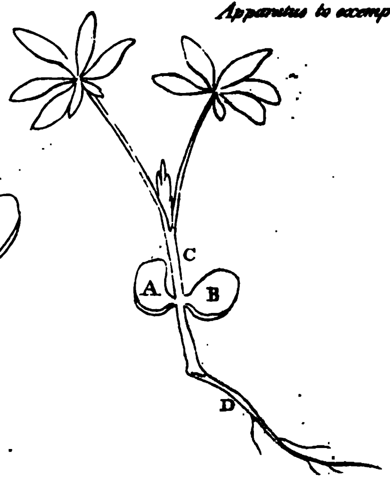
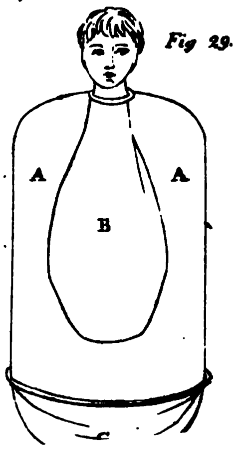


Fig 29.



ut we must not yet take our leave of the subject of culture ; we have prepared the soil, it remains for us to sow the seed. In this operation we must be care- ot to bury it too deep in the ground, as the access ir is absolutely necessary to its germination ; the a therefore must lie loose and light over it, in order the air may penetrate.—Hence the use of plough- and digging, harrowing and raking, &c. A cer- degree of heat and moisture, such as usually takes e in the spring, is likewise necessary.

croline. One would imagine you were going to ribe the decomposition of an old plant, rather than ormation of a new one ; for you have enumerated e requisites of fermentation.

rs. B. Do you forget, my dear, that the young derives its existence from the destruction of the , and that it is actually by the saccharine fermen- n that the latter is decomposed ?

croline. True ; I wonder that I did not recollect The temperature and moisture required for the ination of the seed, is then employed in produc- he saccharine fermentation within it.

rs. B. Certainly. But, in order to understand nature of germination, you should be acquainted the different parts of which the seed is composed. external covering or envelope contains, besides germ of the future plant, the substance which is to titute its first nourishment; this substance, which lled the *parenchyma*, consists of fecula, mucilage, oil, as we formerly observed.

he seed is generally divided into two compart- ts, called *lobes*, or *cotyledons*, as is exemplified by bean, (*Plate* XI. *Fig.* 25.)—the dark coloured of string which divides the lobes, is called the *rad-*

PLATE XI.

ig. 25. Bean.
g. 26. AB. Cotyledons. C. Envelope. D. Radicle.
g. 27. AB. Cotyledons. C. Plumula. D. Radicle.
g. 28. AB. Cotyledons. C. Plumula. D. Radicle.
g. 29. AA. Glass bell. B. Bladder representing the lungs.
Bladder representing the diaphragm.

ture above 40° it imbibes water, which
the lobes; it then absorbs oxygen wh
some of its carbone, and is returned
bonic acid. This loss of carbone i
parative proportion of hydrogen and
and excites the saccharine fermenta
parenchymatoas matter is converted
emulsion. In this form it is carried
vessels for that purpose; and in th
fermentation having caused the see
tyledons are rent asunder, the radi
ground and becomes the root of th
the fermented liquid is conveyed to t
vessels have been previously distend
the fermentation. The plumula bei
it were, by the emulsive fluid, raises
up to the surface of the earth, beari
ledons, which as soon as they come
air, spread themselves, and are transf
If we go into the garden, we shall p
seeds in the state which I have desc

Emily. Here are some lupines th
their appearance above ground.

ke the other leaves which I perceive are just ig to appear.

B. It is because they retain the remains of nchyma, with which they still continue to nou- young plant, as it has not yet sufficient roots and to provide for its sustenance from the soil.— this third lupine, (*Plate* XI. *Fig.* 28.) the ra- l sunk deep into the earth, and sent out seve- s, each of which is furnished with a mouth to nourishment from the soil; the function of the leaves, therefore, being no longer required, gradually decaying, and the plumula is be- regular stem, shooting out small branches and ig its foliage.

. There seems to be a very striking analogy a seed and an egg; both require an elevation erature to be brought to life; both at first sup- aliment the organized being which they pro- nd as soon as this has attained sufficient strength re its own nourishment, the egg-shell breaks, the plant the seed-leaves fall off.

B. There is certainly some resemblance be- these processes; and when you become ac- l with animal chemistry, you will frequently be vith its analogy to that of the vegetable king-

on as the young plant feeds from the soil, it re- ie assistance of leaves, which are the organs by ie plant throws off its superabundant fluid; this is much more plentiful in the vegetable than nimal creation, and the great extent of surface liage of plants is admirably calculated for car- on in sufficient quantities. This transpired isists of little more than water. The sap, by cess, is converted into a liquid of greater con- , which is fit to be assimilated to its several

. Vegetation, then, must be essentially injur- estroying the leaves of the plant?

B. Undoubtedly; it not only diminishes the ation, but also the absorption by the roots; for

But I should inform you that piration seems to be conbined t the leaves, whilst, on the contra which is more rough and uneven kind of hair or down, is destined such other ingredients as the pla mosphere.

As soon as a young plant make ground, light as well as air bec preservation. Light is essential of the colours and to the thrivin may have often observed what a p have for the light. If you make room, they all spread their leav branches towards the windows.

Caroline. And many plants cl soon as it is dark.

Emily. But may not this be dampness of the evening air ?

Mrs. B. That does not appea in a course of curious experiments

I have said that water forms the chief nourishment of plants; it is the basis not only of the sap, but of all the vegetable juices. Water is the vehicle which carries into the plant the various salts and other ingredients required for the formation and support of the vegetable system. Nor is this all; great part of the water itself is decomposed by the organs of the plant; the hydrogen becomes a constituent part of oil, of extract, of colouring matter, &c. whilst a portion of the oxygen enters into the formation of mucilage, of fecula, of sugar, and of vegetable acids. But the greater part of the oxygen, proceeding from the decomposition of the water, is converted into a gaseous state by the caloric, disengaged from the hydrogen during its condensation in the formation of the vegetable materials. In this state the oxygen is transpired by the leaves of plants when exposed to the sun's rays. Thus you find that the decomposition of water, by the organs of the plant, is not only a means of supplying it with its chief ingredient, hydrogen, but at the same time of replenishing the atmosphere with oxygen, a principle which requires continual renovation, to make up for the great consumption of it occasioned by the numerous oxygenations, combustions, and respirations, that are constantly taking place on the surface of the globe.

Emily. What a striking instance of the harmony of nature!

Mrs. B. And how admirable the design of Providence, who makes every different part of the creation thus contribute to the support and renovation of each other!

But the intercourse of the vegetable and animal kingdoms through the medium of the atmosphere extends still farther. Animals, in breathing, not only consume the oxygen of the air, but load it with carbonic acid, which, if accumulated in the atmosphere, would, in a short time, render it totally unfit for respiration. Here the vegetable kingdom again interferes; it attracts and decomposes the carbonic acid, retains the carbone for its own purposes, and returns the oxygen for ours. This process, however, is only carried on during the day, and a contrary one seems to take place during the

night; for the leaves then absorb oxygen and emi
bonic acid. The absorption of carbonic acid durin
day, is, however, far from balanced by the qua
emitted during the night.

Caroline. How interesting this is! I do not kn
more beautiful illustration of the wisdom which is
played in the laws of nature.

Mrs. B. Faint and imperfect as are the ideas w
our limited perceptions enable us to form of D
Wisdom, still they cannot fail to inspire us with
and admiration. What then would be our feelings
the complete system of nature at once displayed b
us! So magnificent a scene would probably be too
for our limited and imperfect comprehension, and
no doubt, amongst the wise dispensations of Provid
to veil the splendour of a glory with which we s
be overpowered.—But it is well suited to the min
a rational being to explore, step by step, the wo
the creation; to endeavour to connect them into
monious systems; and, in a word, to trace, in the
of beings, the kindred ties and benevolent desings
unite its various links, and secure its preservation

Caroline. But of what nature are these org
plants which are endued with such wonderful pow

Mrs. B. They are so minute, that their str
as well as the mode in which they perform their
tions, generally elude our examination; but w
consider them as so many vessels or apparatus
priated to perform, with the assistance of the pr
of life, certain chemical processes, by means of
these vegetable compounds are generated. W
however, trace the tannin, resins, gum, mucilag
some other vegetable materials in the organized a
ment of plants, in which they form the bark, the
the leaves, flowers, and seeds.

The *bark* is composed of the *epidermis*, the
chyma, and the *cortical layers*.

The epidermis is the external covering of th
It is a thin transparent membrane consisting of
ber of slender fibres crossing each other, and f
a kind of net-work. When of a white glossy

veral species of trees, in the stems of corn and
s, it is composed of a thin coating of silicious
which accounts for the strength and hardness of
ong and slender stems. Mr. Davy was led to
covery of the silicious nature of the epidermis of
ants, by observing the singular phenomenon of
of fire emitted by the collision of rattan canes
hich two boys were fighting in a dark room.—
lysing the epidermis of the cane, he found it to
st entirely silicious.

ine. With iron then, a cane I suppose, will
ire very easily?

B. I understand that it will.—In evergreens
idermis is mostly resinous, and in some few
s formed of wax. The resin, from its want of
for water, tends to preserve the plant from the
tive effects of violent rains, severe climates, or
ent seasons, to which this species of vegetables
liarly exposed.

y. Resin must preserve wood just like a var-
s it is the essential ingredient of varnishes.

B. Yes, and by this means it prevents like-
unnecessary expenditure of moisture.

parenchyma is immediately beneath the epider-
t is that green rind which appears when you
branch of any tree or shrub of its external coat
. The parenchyma is not confined to the stem
ches, but extends over every part of the plant.
s the green matter of the leaves, and is com-
f tubes filled with a peculiar juice.

cortical layers are immediately in contact with
od; they abound with tannin and gallic acid, and
of small vessels, through which the sap de-
after being elaborated in the leaves. The corti-
rs are annually renewed, the old bark being
ed into wood.

y. But through what vessels does the sap as-

B. That function is performed by the tubes
alburnum or wood, which is immediately be-
he cortical layers. The wood is composed of

heart-wood; it appears to be dea
functions are discernible in it. It
of the living alburnum that the
therefore, spread into the leaves, a
cate with the extremities of the ve
layers, into which they pour their

Caroline. Of what use then are
renchyma, since neither the ascend
sap passes through them?

Mrs. B. They are supposed to
tant function of secreting from the s
ces from which the plant more imm
nourishment. These juices are v
the vessels which contain them are
those through which the sap circul
juices of plants differ much in thei
different species of vegetablss, but
ent parts of the same individual plan
times saccharine as in the sugar-ca
nous, as in firs and evergreens, so
appearance, as in the laurel.

Emily. I have often observed

man species take delight in them. They scarcely r attack any odoriferous parts of plants, and it is not ommon to see every leaf of a tree destroyed by a ght, whilst the blossoms remain untouched. Cedar, dal, and all aromatic woods, are on this account of at durability.

Emily. But the wood of the oak, which is so much emed for its durability has I believe, no smell.— es it derive this quality from its hardness alone?

Mrs. B. Not entirely; for the chesnut, though con- rably harder and firmer than the oak, is not so ng. The durability of the oak is, I believe, in a at measure owing to its having very little heart- d, the alburnum preserving its vital functions long- han in other trees.

Caroline. If incisions are made into the alburnum cortical layers, may not the ascending and descend- sap be procured in the same manner as the pecu- juice is from the vessels of the parenchyma?

Mrs. B. Yes; but in order to obtain specimens of se fluids, in any quantity, the experiment must be le in the spring, when the sap circulates with the atest energy. For this purpose a small bent glass e should be introduced into the incision, through ch the sap may flow without mixing with any of the er juices of the tree. From the bark the sap will much more plentifully than from the wood, as the ending sap is much more liquid, more abundant, more rapid in its motion than that which descends; the latter having been deprived by the operation of leaves of a consiberable part of its moisture, con- s a much greater proportion of solid matter which rds its motion. It does not appear that there is of descending sap, as none ever exudes from the s of plants; this process, therefore, seems to be ied on only in proportion to the wants of the plant, the sap descends no further and in no greater quan- than is required to nourish the several organs.— refore, though the sap rises and descends in the t, it does not appear to undergo a real circulation.

The last of the organs of plants is the *flower* or blos- which produces the *fruits* and seed. These may

These are the principal organs of
means of which the several chemical p
are carried on during the life of the plan
ed.

Emily. But how are the several p
enter into the composition of vegetabl
by the organs of the plant as to be conv
able matter ?

Mrs. B. By chemical processes, n
apparatus in which they are performed
minute as completely to elude our exa
can form an opinion, therefore, only l
these operations. The sap is evident
water absorbed by the roots, and holdin
various principles which it derives from
the roots the sap ascends through the
burnum into the stem, and thence bran
extremity of the plant. Together wi
lates a certain quantity of carbonic acid
ually disengaged from the former by t
of the plant.

Caroline. What ! have vegetables

, it deposites in the several sets of vessels with h it communicates, the materials on which the th and nourishment of each part depends. It is that the various peculiar juices, saccharine, oily, ous, acid, and colouring, are formed; as also the solid parts of fecula, woody fibre, tannin, resins, 'ete salts: in a word, all the immediate materials getables, as well as the organized parts of plants, 1 latter, besides the power of secreting these from ap, for the general purpose of the plant have also of applying them to their own particular nourish-.

nily. But why should the procoss of vegetation place only at one season of the year, whilst a total ion prevails during the other?

rs. B. Heat is such an important chemical agent, its effect, as such, might perhaps alone account he impulse which the spring gives to vegetation. in order to explain the mechanism of that opera- it has been supposed that the warmth of the spring es the vessels of plants, and produces a kind of ıum, into which the sap (which had remained in a of inaction in the trunk during the winter) rises; is followed by the ascent of the sap contained in the s, and room is thus made for fresh sap, which the s, in their turn pump up from the soil. This pro- goes on till the plant blossoms and bears fruit, ch terminates its summer career; but when the l weather sets in, the fibres and vessels contract, the es wither, and are no longer able to perform their e of transpiration; and, as this secretion stops, the s cease to absorb sap from the soil.—If the plant n annual, its life then terminates; if not, it remains state of torpid inaction during the winter; or the internal motion that takes place is that of a small ntity of resinous juice, which slowly rises from the n into the branches, and enlarges their buds during winter.

aroline. Yet, in evergreens, vegetation must con- e throughout the year.

Mrs. B. Yes; but in winter it goes on in a very im-

perfect manner, compared to the vegetation of spring and summer.

We have dwelt much longer on the history of vegetable chemistry than I had intended; but we have at length, I think brought the subject to a conclusion.

Caroline. I rather wonder that you did not reserve the account of the fermentations for the conclusion; for the decomposition of vegetables naturally follows their death, and can hardly, it seems, be introduced with so much propriety at any other period.

Mrs. B. It is difficult to determine at what point precisely it may be most eligible to enter on the history of vegetation; every part of the subject is so closely connected, and forms such an uninterrupted chain, that it is by no means easy to divide it. Had I begun with the germination of the seed, which, at first view, seems to be the most proper arrangement, I could not have explained the nature and fermentation of the seed, or have described the changes which manure must undergo, in order to yield the vegetable elements. To understand the nature of germination, it is necessary, I think, previously to decompose the parent plant, in order to become acquainted with the materials required for that purpose. I hope, therefore, that, upon second consideration, you will find that the order which I have adopted, though apparently less correct, is in fact the best calculated for the elucidation of the subject.

Conversation XX.

On the Composition of Animals.

Mrs. B.

WE are now come to the last branch of chemistry, which comprehends the most camplicated order of compound beings. This is the animal creation, the history

which cannot but excite the highest degree of curi-ity and interest, though we often fail in attempting to plain the laws by which it is governed.

Emily. But since all animals ultimately derive their urishment from vegetables, the chemistry of this or-r of beings must consist merely in the conversion of getable into animal matter?

Mrs. B. Very true; but the manner in which this is ected, is, in a great measure, concealed from our ob-rvation. This process is called *animalization*, and is rformed by peculiar organs. The difference of the imal and vegetable kingdoms does not, however, de-nd merely on a different arrangement of combinations. new principle abounds in the animal kingdom, which but rarely and in very small quantities found in veg-bles; this is nitrogen. There is likewise in animal stances a greater and more constant proportion of osphoric acid, and other saline matters. But these not essential to the formation of animal matter.

Caroline. Animal compounds contain then four fun-mental principles, oxygen, hydrogen, carbone, and rogen.

Mrs. B. Yes; and these form the immediate mate-ls of animals, which are *gelatine*, *albumen*, and *fibrine*.

Emily. Are those all? I am surprised that animals ould be composed of fewer kinds of materials than getables; for they appear much more complicated their organization.

Mrs. B. Their organization is certainly more per-t and intricate, and the ingredients that occasionally ter into their composition are more numerous. But twithstanding the wonderful variety observable in the xture of the animal organs, we find that the original mpounds, from which all the varieties of animal mat-r are derived, may be reduced to the three heads just ntioned. Animal substances being the most com-cated of all natural compounds, are most easily sus-ptible of decomposition, as the scale of attractions reases in proportion to the number of constituents. eir analysis is, however, both difficult and imper-t; *for as they* cannot be examined in their living

state, and are liable to alteration immediately after death, it is probable that, when submitted to the investigation of a chemist, they are always more or less altered in combinations and properties, from what they were whilst they made part of the living animal.

Emily. The mere diminution of temperature, which they experience by the privation of animal heat, must, I should suppose, be sufficient to derange the order of attractions that existed during life.

Mrs. B. That is one of the causes, no doubt: but there are many other circumstances which prevent us from studying the nature of living animal substances. We must therefore, in a considerable degree, confine our researches to the phenomena of these compounds in their inanimate state.

These three kinds of animal matter, gelatine, albumen, and fibrine, form the basis of all the various parts of the animal system; either solid, as the skin, flesh, *nerves*, *membranes*, *cartilages*, and *bones*; or fluids, as the *blood*, *chyle*, *milk*, the *gastric* and *pancreatic juices*, bile, *perspiration*, *saliva*, *tears*, *&c.*

Caroline. Is it not surprising that so great a variety of substances, and so different in their nature, should yet all arise from so few materials, and from the same original elements?

Mrs. B. The difference in the nature of many bodies depends, as I have often observed to you, more on their state of combination, than on the materials of which they are composed. Thus, in considering the chemical nature of the creation in a general point of view, we observe that it is throughout composed of a very small number of elements. But when we divide it into the three kingdoms, we find that, in the mineral, the combinations seem to result from the union of elements casually brought together; whilst in the vegetable and animal kingdoms, the attractions are peculiarly and regularly produced by appropriate organs, whose action depends on the vital principle. And we may further observe, that by means of certain spontaneous changes and decompositions, the elements of one kind of matter become subservient to the production of another; so that the three kingdoms are intimately connected.

nd constantly contributing to the preservation of each ther.

Emily. There is, however, one very considerable lass of elements, which seems to be confined to the nineral kingdom: I mean metals.

Mrs. B. Not entirely; they are found, though in very minute quantities, both in the vegetable and animal kingdoms. A small portion of earth and sulphur enters also into the composition of organized bodies. Phosphorus, however, is almost entirely confined to the animal kingdom; and nitrogen, but with few exceptions, is extremely scarce in vegetables.

Let us now proceed to examine the nature of the three principal materials of the animal system.

Gelatine, or *jelly*, is the chief ingredient of skin, and of all the membranous parts of animals. It may be obtained from these substances under the forms of glue, size, isinglass, and transparent jelly.

Caroline. But these are of a very different nature; they cannot therefore be all pure gelatine.

Mrs. B. Not entirely, but very nearly so. Glue is extracted from the skin of animals. Size is obtained either from skin in its natural state, or from leather. Isinglass is gelatine procured from a particular species of fish; it is, you know, of this substance that the finest jelly is made, and this is done by merely dissolving the isinglass in boiling water, and allowing the solution to congeal.

Emily. The wine, lemon, and spices, are, I suppose, added only to flavour the jelly?

Mrs. B. Exactly so,

Caroline. But jelly is often made of hartshorn shavings, and of calves' feet; does these substances contain gelatine?

Mrs. B. Yes. Gelatine may be obtained from almost any animal substance, as it enters more or less into the composition of all of them. The process of obtaining it is extremely simple, as it consists merely in boiling the substance that contains it with water. The gelatine dissolves in water, and may be obtained of any degree of consistence or strength, by evaporating this

solution. Bones in particular produce it very plentiful-ly, as they consist of phosphat of lime combined or cemented by gelatine. Horns which are a species of bone, will yield abundance of gelatine. The horns of the hart are reckoned to produce gelatine of the first quality; they are reduced to the state of shavings in order that the jelly may be more easily extracted by the water. It is of hartshorn shavings that the jellies for invalids are usually made, as they are of very easy digestion.

Caroline. It appears singular that hartshorn, which yields such a powerful ingredient as ammonia, should at the same time produce so mild and insipid a substance as jelly?

Mrs. B. And, what is more surprising, it is from the gelatine of bones that ammonia is produced.—You must observe, however, that the processes by which these two substances are obtained from bones are very different. By the simple action of water, and heat, the gelatine is separated; but in order to procure the ammonia, or what is commonly called hartshorn, the bones must be distilled, by which means the gelatine is decomposed, and hydrogen and nitrogen combined in the form of ammonia. So that the first operation is a mere separation of ingredients, whilst the second requires a chemical decomposition.

Caroline. But when jelly is made from hartshorn shavings, what becomes of the phosphat of lime which constitutes the other part of bones?

Mrs. B. It is easily separated by straining. But the jelly is afterwards more perfectly purified, and rendered transparent by adding white of egg, which being coagulated by heat, rises to the surface along with any impurities.

Emily. I wonder that bones are not used by the common people to make jelly; a great deal of wholesome nourishment might, I should suppose, be procured from them, though the jelly would perhaps not be quite so good as if made from hartshorn shavings?

Mrs. B. There is a kind of prejudice among the poor against a species of food that is usually thrown

e dogs ; and as we cannot expect them to enter into emical considerations, it is in some degree excusable. sides, it requires a prodigious quantity of fuel to dislve bones and obtain the gelatine from them.

The solution of bones in water is greatly promoted an accumulation of heat. This may be effected by eans of an extremely strong metallic vessel, called *pin's digester*, in which the bones and water are enosed, without any possibility of the steam making its cape. A heat can thus be applied much superior to it of boiling water ; and bones, by this means, are npletely reduced to a pulp. But the process still sumes too much fuel to be generally adopted among lower classes.

Caroline. And why should not a manufacture be esished for grinding or macerating bones, or at least reducing them to the state of shavings, when I pose they would dissolve as readily as hartshorn vings?

Mrs. B. Indeed I see no objection to this plan, if prejudices of the vulgar could be overcome ; but would be a difficult matter, for I have even heard bjected to Papin's digester, that by the use of food s prepared, the flesh of those feeding upon it would ome ossified.

Caroline. But these prejudiced people might easily that the flesh of dogs, who feed chiefly on bones, is ossified. Besides it would not be difficult to conce them that the real bony matter, the phosphat of e, is deposited and forms no part of the jelly.

Emily. And when jelly is made of isinglass, does it ve no sediment ?

Mrs. B. No ; nor does it so much require clarifys as it consists almost entirely of pure gelatine, and foreign matter that is mixed with it, is thrown off ing the boiling in the form of scum. These are cesses which you may see performed in great pertion in the culinary labratory, by that very able and st useful chemist the cook.

Caroline. To what an immense variety of purposes emistry is subservient !

Emily. It appears, in that respect, to have an advantage over most other arts and sciences; for these very often have a tendency to confine the imagination to their own particular object, whilst the pursuit of chemistry is so extensive and diversified, that it inspires a general curiosity, and a desire of inquiring into the nature of every object.

Caroline. I suppose that soup is likewise composed of gelatine; for when cold, it often assumes the consistence of jelly?

Mrs. B. Yes; all soups contain a quantity of gelatine obtained from meat, and dissolved in water. And the various kinds of portable soups consist almost entirely of concentrated jelly, which, in order to be made into soup, requires only to be dissolved in water.

Gelatine, in its solid state, is a semiductile transparent substance, without either taste or smell.—When exposed to heat, in contact with air and water, it first swells, then fuses, and finally burns. You may have seen the first part of this operation performed in the carpenter's glue-pot.

Caroline. But you said that gelatine had no smell, and glue has a very disagreeable one.

Mrs. B. Glue is not purely gelatine; but like size, the smell of which is still more offensive, it retains some other particles of animal matter.

Gelatine may be precipitated from its solution in water by alcohol.—We shall try this experiment with a glass of warm jelly.—You see that the gelatine subsides by the union of the alcohol and the water.—

Emily. How is it, then, that jelly is flavoured with wine, without producing any precipitation?

Mrs. B. Because the alcohol contained in wine is already combined with water and other ingredients, and is therefore not at liberty to act upon the jelly as when in its separate state. Gelatine is soluble both in acids and in alkalies; the former, you know, are frequently used to season jellies.

Caroline. Among the combinations of gelatine we must not forget one which you formerly mentioned, that with tannin, to form leather.

Mrs. B. True; but you must observe that leather be produced only by gelatine in a membraneous ; for though pure gelatine and tannin will pro- a substance chemically similar to leather, yet the ture of the skin is requisite to make it answer the ful purposes of that substance.

The next animal substance we are to examine is *al- men*: this, although constituting part of most of the mal compounds, is frequently found insulated in the mal system; the white of egg, for instance, con- s almost entirely of albumen; the substance that nposes the nerves, the serum, or white part of the od, and the curds of milk, are little else than albu- n variously modified.

In its most simple state, albumen appears in the form a transparent viscous fluid, possessed of no distinct ste or smell; it coagulates at the low temperature of 50, and when once solidified, it will never return to fluid state.

Sulphuric acid and alcohol are each of them capable coagulating albumen in the same manner as heat, as am going to shew you—

Emily. Exactly so.—Pray, Mrs. B. what kind of tion is there between albumen and water? I have metimes observed, that if the spoon with which I eat egg happens to be wetted, it becomes tarnished.

It is because the white of egg (and indeed albumen general) contains a little sulphur, which, at the tem- erature of an egg just boiled, will decompose the op of water that wets the spoon, and produce sulphu- ated hydrogen gas, which has the property of tarnish- g silver.

We may now proceed to *Fibrine.* This is an insipid d inodorous substance, having somewhat the appear- ce of fine white threads adhering together; it is the ssential constituent of muscles or flesh, in which it is ixed with and softened by gelatine. It is insoluble oth in water and alcohol, but sulphuric acid converts into a substance very analagous to gelatine.

These are the essential and general ingredients of nimal matter; but there are other substances, which

though not peculiar to the animal system, usually enter into its composition, such as oils, acids, salts, &c.

Animal Oil is the chief constituent of fat; it is contained in abundance in the cream of milk, whence it is obtained in the form of butter.

Emily. Is animal oil the same in its composition as vegetable oils?

Mrs. B. Not the same, but very analagous. The chief difference is that animal oil contains nitrogen, a principle that seldom enters into the composition of vegetable oils, and never in so large a proportion.

There are a few animal acids, that is to say, acids peculiar to animal matter, from which they are almost exclusively obtained.

The animal acids have triple bases of hydrogen, carbone, and nitrogen. Some of them are found native in animal matter; others are produced during its decomposition.

Those that we find ready formed are:

The *bombic acid,* which is obtained from silkworms.

The *formic acid,* from ants.

The *lactic acid,* from the whey of milk.

The *sebacic* from oil or fat.

Those produced during the decomposition of animal substances by heat, are the *prussic* and *zoonic* acids.— This last is produced by the roasting of meat, and gives it a brisk flavour.

Caroline. The class of animal acids is not very extensive.

Mrs. B. No; nor are they, generally speaking, of great importance. The prussic acid is, I think, the only one sufficiently interesting to require any further comment. It can be formed by an artificial process, without the presence of any animal matter; and it may likewise be obtained from a variety of vegetables, particularly those of the narcotic kind, such as poppies, laurel, &c. But it is commonly obtained from blood, by strongly heating that substance with caustic potash; the alkali attracts the acid from the blood, and forms with it a *prussiat of potash.* From this state of combi-

n the prussic acid can be obtained pure by means
ier substances which have the power of separating
m the alkali.

nily. But if this acid does not exist ready formed
ood, how can the alkali attract it from it?

rs. B. It is the triple bases only of this acid that
s in the blood; and this is developed and brought
: state of acid, during the combustion. The acid
fore is first formed, and it afterwards combines
the potash.

nily. Now I comprehend it. But how can the
sic acid be artificially made?

rs. B. By passing ammoniacal gas over red hot
coal; and hence we learn that the constituents of
acid are hydrogen, nitrogen, and carbone. The
first are derived from the volatile alkali, the last
the combustion of the charcoal.

iroline. But this does not accord with the system
:ygen being the indispensable principle of acidity?

rs. B. It is true; and this circumstance, togeth-
ith some others of the same kind, has led several
nists to suspect that oxygen may not be the sole
:rator of acids, and that acidity may possibly depend
er on the arrangement than on the presence of any
icular principles.

aroline. I do not like that idea. For if it were
ded, all our theory of chemistry must be erroneous.

Irs. B. The objection is yet so new and uncon-
ed by common experience, that I confess I do not
inclined to distrust the general doctrine of acidifi-
on which we have hitherto adopted. But we have
yet done with the prussic acid. It has a strong
ity for metallic oxyds, and precipitates the solu-
of iron in acids of a blue colour. This is the prus-
blue, or prussiat of iron, so much used in the arts,
with which I think you must be acquainted.

Emily. Yes, I am; it is much used in painting,
i in oil and in water colours; but it is not reckoned
:rmanet oil colour.

Mrs. B. That defect arises, I believe, in general,
n its being badly prepared, which is the case when

the iron is not so fully oxydated as to form a red For a solution of green oxyd of iron (in whi metal is more slightly oxydated) makes only green, or even a white precipitate, with pru potash; and this gradually changes to blue by exposed to the air, as I can immediately shew yo

Caroline. It already begins to assume a pal colour. But how does the air produce this chan

Mrs. B. By oxydating the iron more perfectly we pour some nitrous acid on it, the prussian blu lour will be immediately produced, as the acid yield its oxygen to the precipitate, and fully satu with this principle—as you shall see—

Caroline. It is very curious to see a colour ch so instantaneously.

Mrs. B. Hence you perceive that prussian cannot be a permanent colour unless prepared red oxyd of iron, since by exposure to the atmosp it gradually darkens, and in a short time is no lo in harmony with the other colours of the painting.

Caroline. But it can never become darker, by posure to the atmosphere, than the true prussian b in which the oxyd is perfectly saturated?

Mrs. B. Certainly not. But in painting, the ist not reckoning upon partial alterations in his col gives his blue tints that particular shade which harm izes with the rest of the picture. If, afterwards th tints become darker, the harmony of the colouring n necessarily be destroyed.

Caroline. Pray, of what nature is the paint c *carmine?*

Mrs. B. It is an animal colour, prepared from *chineal*, an insect, the infusion of which produces a beautiful red.

Caroline. Whilst we are on the subject of col I should like to learn what *ivory black* is?

Mrs. B. It is a carbonaceous substance obtain the combustion of ivory. A more common spe black is obtained from the burning of bone.

Caroline. But during the combustion of iv

one, the carbone I should have imagined, must be onverted into carbonic acid gas, instead of this black ubstance!

Mrs. B. In this, as in most combustions, a considerable part of the carbone is simply volatilized by the eat, and again obtained concrete on cooling.—This olour, therefore, may be called the soot produced by ie burning of ivory or bone.

Conversation XXI.

On the Animal Economy.

Mrs. B.

We have now acquired some idea of the various maials that compose the animal system; but if you are rious to know in what manner these substances are rmed by the animal organs, from vegetable, as well from animal substances, it will be necessary to have me previous knowledge of the nature and functions these organs, without which it is impossible to form y distinct idea of the processes of *animalization* and *trition.*

Caroline. I do not exactly understand the meaning the word animalization?

Mrs. B. Animalization is the process by which the od is *assimilated*, that is to say, converted into animal atter; and nutrition is that by which the food thus similated is rendered subservient to the purposes of urishing and maintaining the animal system.

Emily. This, I am sure, must be the most interting of all the branches of chemistry.

Caroline. So I think; particularly as I expect that

we shall hear something of the nature of respiration, and of the circulation of the blood?

Mrs. B. These functions undoubtedly occupy a most important place in the history of the animal economy.—But I must previously give you a very short account of the principal organs by which the various operations of the animal system are performed.—These are:

The *Bones*,
Muscles,
Blood vessels,
Lymphatic vessels,
Glands, and
Nerves.

The *bones* are the most solid part of the animal frame and in a great measure determine its form and dimensions. You recollect, I suppose, what are the ingredients which enter into their composition?

Caroline. Yes; phosphat of lime, cemented by gelatine.

Mrs. B. During the earliest period of animal life they consist almost entirely of a gelatinous membrane of the form of the bones, but of a loose spongy texture, the cells or cavities of which are destined to be filled with phosphat of lime; it is the gradual acquisition of this salt which gives to the bones their subsequent hardness and durability. Infants first receive it from their mother's milk, and afterwards derive it from all animal and from most vegetable food, especially farinaceous substances, such as wheat flour, which contain it in sensible quantities. A portion of the phosphat after the bones of the infant have been sufficiently expanded and solidified, is deposited in the teeth, which consist at first of only a gelatinous membrane or case, fitted for the reception of this salt; and which, after acquiring hardness within the gum, gradually protrude from it.

Caroline. How very curious this is: and how ingeniously nature has first provided for the solidification of such bones as are immediately wanted, and afterwards for the formation of the teeth, which would not only be useless, but detrimental in infancy!

Mrs. B. In quadrupeds the phosphat of lime is de-
ited likewise in their horns, and in the hair or wool
h which they are generally clothed.

In birds it serves also to harden the beaks and the
ills of their feathers.

When animals are arrived at a state of maturity, and
ir bones have acquired a sufficient degree of solid-
, the phosphat of lime which is taken with the food
eldom assimilated, excepting when the female nour-
s her young; it is then all secreted into the milk,
provision for the tender bones of the nursling.

Emily. So that whatever becomes superfluous to
being, is immediately wanted by another; and the
d acquires strength precisely by the species of nour-
ent which is no longer necessary to the mother.
re is, indeed, an admirable economist!

Caroline. Pray, Mrs. B. does not the disease in the
s of children, called the rickets, proceed from a
iency of phosphat of lime?

Mrs. B. I have heard that this disease may arise
two causes; it is sometimes occasioned by the
th of the muscles being too rapid in proportion to
of the bones. In this case the weight of the flesh
reater than the bones can support, and presses up-
em so as to produce a swelling of the joints which
e great indication of the rickets. The other cause
is disorder is an imperfect digestion and assimila-
of the food, attended with an excess of acid, which
teracts the formation of phosphat of lime. In both
nces, therefore, care should be taken to alter the
l's diet, not merely by increasing the quantity of
ent containing phosphat of lime, but also by avoid-
all food that is apt to turn acid on the stomach and
luce indigestion. But the best preservative against
plaints of this kind is, no doubt, good nursing;
n a child has plenty of air and exercise, the diges-
and assimilation will be properly performed, no
d will be produced to interrupt these functions, and
muscles and bones will grow together in just pro-
tions.

Caroline. I have often heard the rickets attributed to

bad nursing, but I never could have guessed what connection there was between exercise and the formation of the bones.

Mrs. B. Exercise is generally beneficial to all the animal functions. If man is destined to labour for his subsistence, the bread which he earns is scarcely more essential to his health and preservation than the exertions by which he obtains it. Those whom the gifts of fortune have placed above the necessity of bodily labour, are compelled to take exercise in some mode or other; and when they cannot convert it into an amusement, they must submit to it as a task, or their health will soon experience the effects of their indolence.

Emily. That will never be my case: for exercise, unless it becomes fatigue, always gives me pleasure, and, so far from being a task, is to me a source of lively enjoyment. I often think what a blessing it is, that exercise which is so conducive to health, should be delightful, whilst fatigue which is rather hurtful, instead of pleasure occasions painful sensations. So fatigue, no doubt, was intended to moderate our bodily exertions, as satiety puts a limit to our appetites?

Mrs. B. Certainly.—But let us not deviate too far from our subject.—The bones are connected together by ligaments, which consist of a white thick fle... substance, adhering to their extremities, so far as to secure the joints firmly, though without impeding their motion. And the joints are moreover covered with a solid smooth, elastic, white substance, called cartilage, the use of which is to allow, by its smoothness and elasticity, the bones to slide easily over one another, so that the joints may perform their office without difficulty or detriment.

Over the bones the *muscles* are placed; they consist of bundles of fibres which terminate in a kind of tendon or ligament, by which they are fastened to the bones. The muscles are the organs of motion; by their power of dilatation and contraction they put into action the bones, which act as leavers in all the motions of the body, and form the solid support of its various parts. The muscles are of various degrees of strength

nce in different species of animals. The mammif-
s tribe, or those that suckle their young, seem in
respect to occupy an intermediate place between
. and cold-blooded animals, such as reptiles and
s.

nily. The different degrees of firmness and so-
- in the muscles of these several species of ani-
proceed, I imagine, from the different nature of
ood on which they subsist?

rs. B. No; that is not supposed to be the case:
ie human species, who are of the mammiferous
, live on more substantial food than birds, and yet
latter exceed them in muscular strength.—We
hereafter attempt to account for this difference;
et us now proceed in the examination of the animal
ions.

he next class of organs is that of the *vessels* of the
, the office of which is to convey the various fluids
ighout the frame. These vessels are innumera-
The most considerable of them are those thro'
h the blood circulates, which are of two kinds:
rteries, which convey it from the heart to the ex-
ities of the body, and the *veins*, which bring it
into the heart.

sides these, there are a numerous set of small
parent vessels, destined to absorb and convey dif-
t fluids into the blood; they are generally called
bsorbent or *lymphatic* vessels: but it is to a portion
em only that the function of conveying into the
the fluid called *lymph* is assigned.

nily. Pray what is the nature of that fluid?

rs. B. The nature and use of the lymph have, I
ve, never been perfectly ascertained; but it is sup-
l to consist of matter that has been previously an-
zed, and which, after answering the purpose for
h it was intended, must in regular rotation
for the fresh supplies produced by nourisl
lymphatic vessels pump up this fluid from
of the system, and convey it into the veins
d with the blood which runs through them
is commonly called venous blood.

Caroline. But does it not again enter into the animal system through that channel?

Mrs. B. Not entirely; for the venous blood does not return into the circulation until it has undergone a peculiar change, in which it throws off whatever is become useless.

Another set of absorbent vessels pump up the chyle from the stomach and intestines, and convey it, after many circumvolutions, into the great vein near the heart.

Emily. Pray what is chyle?

Mrs. B. It is the substance into which food is converted by digestion.

Caroline. One set of the absorbent vessels, then, is employed in bringing away the old materials that are no longer fit for use; whilst the other set is busy in conveying into the blood the new materials that are to replace them.

Emily. What a great variety of ingredients must enter into the composition of the blood!

Mrs. B. You must observe that there is also a great variety of substances to be secreted from it. We may compare the blood to a general receptacle or storehouse for all kinds of commodities which are afterwards fashioned, arranged, and disposed of as circumstances require.

There is another set of absorbent vessels in females which is destined to secrete milk for the nourishment of the young.

Emily. Pray is not milk very analogous in its composition to blood; for, since the nursling derives its nourishment from that source only, it must contain every principle which the animal system requires?

Mrs. B. Very true. Milk is found, by its analysis, to contain all the principal materials of animal matter, gelatine, albumen, oil, and phosphat of lime; so that the suckling has but little trouble to digest and assimilate this nourishment. But we shall examine the composition of milk more fully afterwards.

In many parts of the body numbers of small vessels

collected together in little bundles called *glands*, a Latin word meaning *acorn*, on account of the nblance which some of them bear in shape to that . The function of the glands is to *secrete*, or sep certain matters from the blood.

he secretions are not only mechanical, but chemi- eparations from the blood; for the substances thus ed, though contained in the blood, are not ready bined in that fluid. The secretions are of two s, those which form peculiar animal fluids, as bile, saliva, &c. and those which produce the general rials of the animal system, for the purpose of re- ing and nourishing the several organs of the body; as albumen, gelatine, and fibrine; the latter may istinguished by the name of *nutritive secretions*.

aroline. I am quite astonished to hear that all the etions should be derived from the blood.

nily. I thought that the bile was produced by the ?

Irs. B. So it is; but the liver is nothing more than ry large gland, which secretes the bile from the d.

he last of the animal organs which we have men- ed are the *nerves;* these are the vehicles of sensa- every other part of the body being, of itself totally nsible.

aroline. They must then be spread throughout ry part of the frame, for we are every where sus- tible of feeling.

Emily. Excepting the nails and the hair.

Mrs. B. And those are almost the only parts in ich nerves cannot be discovered. The common rce of all the nerves is the brain; thence they de- nd, some of them through different holes of the ll, but the greatest part through the back bone, and end themselves by innumerable ramifications through- the whole body. They spread themselves over muscles, penetrate the glands, wind round the vas- ar system, and even pierce into the interior of the es. It is most probably through them that the com- nication is carried on between the mind and the oth-

er parts of the body; but in what manner they are act-ed upon by the mind, and made to re-act on the body, is still a profound secret. Many hypotheses have been formed on this very obscure subject, but they are all equally improbable, and it would be useless for us to waste our time in conjectures on an inquiry which in all probability, is beyond the reach of human capacity.

Caroline. But you have not mentioned those particular nerves that form the senses of hearing, seeing, smelling, and tasting?

Mrs. B. They are considered as being of the same nature as those which are dispersed over every part of the body, and constitute the general sense of feeling. The different sensations which they produce arise from their peculiar situation and connection with the several organs of taste, smell, and hearing.

Emily. But these senses appear totally different from that of feeling?

Mrs. B. They are, all of them sensations, but variously modified according to the nature of the different organs in which the nerves are situated. For, as we have formerly observed, it is by contact only that the nerves are affected. Thus odoriferous particles must strike upon the nerves of the nose in order to excite the sense of smelling, in the same manner that taste is produced by the particular substance coming into contact with the nerves of the palate. It is thus also that the sensation of sound is produced by the concussion of the air striking against the auditory nerve; and sight is the effect of the light falling upon the optic nerve. These various senses, therefore, are affected only by the actual contact of particles of matter, in the same manner as that of feeling.

The different organs of the animal body, though easily separable and perfectly distinct, are loosely connected together by a kind of spongy substance, in texture somewhat resembling net-work, called the cellular membrane; and the whole is covered by the skin.

The *skin*, as well as the bark of vegetables, is formed of three coats. The external one is called the *cuticle*, or *epidermis*; the second, which is called the *mucous membrane*, is of a thin soft texture, and con-

ucous substance, which in negroes is black, and is cause of their skin appearing of that colour.

aroline. Is then the external skin of negroes white ours?

rs. B. Yes; but as the cuticle is transparent, as as porus, the blackness of the mucous membrane isible through it. The extremities of the nerves are ad over the skin, so that the sensation of feeling is smitted through the cuticle. The internal cover- of the muscles, which is properly the skin, is the est, the toughest, and most resisting of the whole is this membrane that is so essential in the arts, by ing leather when combined with tannin.

he skin which covers the animal body, as well as e membranes that form the coats of the vessels, st almost exclusively of gelatine; and are capable ing converted into glue, size, or jelly.

he cavities between the muscles and the skin are lly filled with fat, which lodges in the cells of the branous net before mentioned, and gives to the rnal form (especially in the human figure) that dness, smoothness, and softness, so essential to ty.

mily. And the skin itself is, I think, a very orna- tal part of the human frame, both from the finess s texture, and the variety and delicacy of its tints.

rs. B. This variety and harmonious gradation of urs, proceed, not so much from the skin itself, as the internal organs which transmit their several urs through it, these being only softened and blen- by the colour of the skin, which is uniformly of a owish white.

hus modified, the darkness of the veins appears of le blue colour, and the floridness of the arteries is nged to a delicate pink. In the most transparent s, the skin exhibits the bloom of the rose, whilst re it is more opaque its own colour predominates; at the joints, where the bones are most prominent, r whiteness is often discernible. In a word, every t of the human frame seems to contribute to its ex- nal grace; and this not merely by producing a

pleasing variety of tints, but by a peculiar kind of beauty which belongs to each individual part. Thus it is to the solidity and arrangement of the bones that the human figure owes the grandeur of its stature, and its firm and dignified deportment. The muscles delineate the form, and stamp it with energy and grace; and the soft substance which is spread over them smooths their ruggedness, and gives to the contours the gentle undulations of the line of beauty. Every organ of sense is a peculiar and separate ornament; and the skin, which polishes the surface and gives it that charm of colouring so inimitable by art, finally conspires to render the whole the fairest work of the creation.

But now that we have seen in what manner the animal frame is formed, let us observe how it provides for its support, and how the several organs, which form so complete a whole, are nourished and maintained.

This will lead us to a more particular explanation of the internal organs: here we shall not meet with so much apparent beauty, because these parts were not intended by nature to be exhibited to view; but the beauty of design, in the internal organization of the animal frame, is, if possible, still more striking than that of the external part.

We shall defer this subject until our next interview.

Conversation XXII.

On Animalization, Nutrition, and Respiration.

Mrs. B.

We have now learnt of what materials the animal stem is composed, and have formed some idea of e nature of its organization. In order to complete the bject, it remains for us to examine in what manner s nourished and supported.

Vegetables we have observed, obtain their nourishent from various substances, either in their elementa- state, or in a very simple state of combination; as rbone, water, and salts, which they pump up from e soil; and carbonic acid and oxygen, which they sorb from the atmosphere.

Animals, on the contrary, feed on substances of the ost complicated kind: for they derive their sustence, some from the animal creation, others from the getable kingdom, and some from both.

Caroline. And there is one species of animals, hich, not satisfied with enjoying either kind of food in simple state, has invented the art of combining em together in a thousand ways, and of rendering en the mineral kingdom subservient to their refinents.

Emily. Nor is this all; for our delicacies are colcted from the various climates of the earth, so that e four quarters of the globe are often obliged to conbute to the preparation of our simplest dishes.

Caroline. But the very complicated substances which nstitute the nourishment of animals, do not, I suppse, enter into their system in their actual state of mbination.

Mrs. B. So far from it, that they not only undergo new arrangement of their parts, but a selection is

made of such as are most proper for the nou
of the body, and those only enter into the syst
are animalized.

Emily. And by what organs is this process
ed?

Mrs. B. Chiefly by the stomach, which i
gan of digestion, and the prime regulator of
mal frame.

Digestion is the first step towards nutrition.
sists in reducing into one homogenous mass t
ous substances that are taken as nourishmen
performed by first chewing and mixing the
ment with the saliva, which reduces it to a so
in which state it is conveyed into the stomach
it is more completely dissolved by the *gastric j*

This fluid (which is secreted into the sto
appropriate glands) is so powerful a solvent tha
ly any substances will resist its action.

Emily. The coats of the stomach however
be attacked by it, otherwise we should be in d
having them destroyed when the stomach was

Mrs. B. They are probably not subject t
tion; as long at least as life continues. But it
that when the gastric juice has no foreign sub
act upon, it is capable of occasioning a degree
tion in the coats of the stomach, which prod
sensation of hunger. The gastric juice toget
the heat and muscular action of the stomach,
the aliment into a uniform pulpy mass called
This passes into the intestines, where it me
the bile and some other fluids, by the agency
and by the operation of other causes hitherto
the chyme is changed into chyle, a much thin
stance, somewhat resembling milk, which is
up by immense numbers of small absorben
spread over the internal surface of the intestine
after many circumvolutions, gradually meet a
into large branches, till they at length collect
into one vessel, which pours its contents into
vein near the heart, by which means the f
prepared, enters into the circulation.

aroline. But I do not yet clearly understand how olood, thus formed, nourishes the body and supplies he secretions.

Irs. B. Before this can be explained to you, you st first allow me to complete the formation of the od. The chyle may indeed be considered as form- the chief ingredient of blood; but this fluid is not ect until it has passed through the lungs, and un- gone (together with the blood that has already cir- ated) certain necessary changes that are effected by PIRATION.

aroline. I am very glad that you are going to ex- n the nature of respiration: I have often longed to erstand it, for though we talk incessantly of breath- I never knew precisely what purpose it answered.

Irs. B. It is indeed one of the most interesting esses imaginable; but in order to understand this tion well, it will be necessary to enter into some ious explanations. Tell me, Emily, what do you rstand by respiration?

mily. Respiration, I conceive, consists simply in nately *inspiring* air into the lungs, and *expiring* it them.

Irs. B. Your answer will do very well as a gener- efinition. But, in order to form a tolerably clear n of the various phenomena of respiration, there many circumstances to be taken into consideration. the first place, there are two things to be distin- hed in respiration, the *mechanical* and the *chemical* of the process.

he mechanism of breathing depends on the alter- expansions and contractions of the chest, in which lungs are contained. When the chest dilates the ty is enlarged, and the air rushes in at the mouth, ll up the vacuum formed by this dilatation; when ntracts, the cavity is diminished, and the air for- out again.

aroline. I thought that it was the lungs that con- ted and expanded in breathing?

Irs. B. They do likewise; but their action is on- he *consequence* of that of the chest. The lungs,

together with the heart and the largest blood in a manner fill up the cavity of the chest; th not, therefore, dilate if the chest did not previo pand; and, on the other hand, when the ch tracts, it compresses the lungs and forces th of them.

Caroline. The lungs, then, are like bell the chest is the power that works them.

Mrs. B. Precisely so. Here is a curious gure (*Plate* XI. *Fig* 29), that will assist me in ing the mechanism of breathing.

Caroline. What a droll figure! a little he upon a glass bell, with a bladder tied over th of it!

Mrs. B. You must observe that there is bladder within the glass, the neck of which c cates with the mouth of the figure—this repre lungs contained within the chest; the other which you see is tied loose, represents a membrane, called the *diaphragm*, which sepa chest from the lower part of the body. By therefore, I mean that large cavity in the u of the body contained within the ribs, the the diaphragm; this membrane is muscular ble of contraction and dilatation. The contra be imitated by drawing the bladder tight ov tom of the receiver, when the air, in the blad represents the lungs, will be forced out th mouth of the figure—

Emily. See, Caroline, how it blows the fl candle in breathing!

Mrs. B. By letting the bladder loose imitate the dilatation of the diaphragm, an of the chest being enlarged, the lungs expa air rushes in to fill them.

Emily. This figure, I think, gives a ver of the process of breathing.

Mrs. B. It illustrates tolerably well t the lungs and diaphragm; but those are powers that are concerned in enlarging or the cavity of the chest; the ribs are also

ar motion for the same purpose; they are al· drawn in edgeways to assist the contraction, tched out, like the hoops of a barrel, to con- the dilatation of the chest.

I always supposed that the elevation and on of the ribs were the consequence, not the f breathing.

B. It is exactly the reverse. The muscular the diaphragm, together with that of the ribs, *causes* of the contraction and expansion of the nd the air rushing into, and being expelled lungs, are only *consequences* of those actions.

ie. I confess that I thought the act of breath- n by opening the mouth for the air to rush in, it was the air alone, which, by alternately in and out, occasioned the dilatations and con- of the lungs and chest.

B. Try the experiment of merely opening uth; the air will not rush in, till by an interior action you produce a vacuum—yes, just so, phragm is now dilated, and the ribs expanded. will not be able to keep them long in that state. gs and chest are already resuming their former d expelling the air with which they had just d. This mechanism goes on more or less but in general, a person at rest and in health the between fifteen and twenty-five times in a

nay now proceed to the chemical effects of res- ; but, for this purpose, it is necessary that you reviously have some notion of the *circulation* of l. Tell me, Caroline, what do you under- the circulation of the blood?

ne. I am delighted that you come to that sub- it is one that has long excited my curiosity.— nnot conceive how it is connected with respira- he idea I have of the circulation is, that the s from the heart through the veins all over the d back again to the heart.

B. I could hardly have expected a better de- rom you; it is, however, not quite correct,

for you do not distinguish the *arteries* from the veins, which, as we have already observed, are two distinct sets of vessels, each having its own particular functions. The arteries convey the blood from the heart to the extremities of the body; and the veins bring it back to the heart.

This sketch will give you an idea of the manner in which some of the principal veins and arteries of the human body branch out of the heart, which may be considered as a common centre to both sets of vessels. The heart is a kind of strong elastic bag, or muscular cavity, which possesses a power of dilating and contracting itself, for the purpose of alternately receiving and expelling the blood, in order to carry on the process of circulation.

Emily. Why are the arteries in this drawing painted red, and the veins purple?

Mrs. B. It is to point out the difference of the colour of the blood in these two sets of vessels.

Caroline. But if it is the same blood that flows from the arteries into the veins, how can its colour be changed?

Mrs. B. This change arises from various circumstances. In the first place, during its passage through the arteries, the blood undergoes a considerable alteration, some of its constituent parts being gradually separated from it for the purpose of nourishing the body, and of supplying the various secretions. The consequence of this is, that the florid arterial colour of the blood changes by degrees to a deep purple, which is its constant colour in the veins. On the other hand the blood is recruited during its return through the veins by the fresh chyle, or imperfect blood, which has been produced by food; and it receives also lymph from the absorbent vessels, as we have before mentioned. In consequence of these several changes, the blood returns to the heart in a state very different from that in which it left it. It is loaded with a greater proportion of hydrogen and carbone, and is no longer fit for the nourishment of the body or other purposes of circulation.

Emily. And in this state does it mix in the heart with the pure florid blood that runs into the arteries?

Mrs. B. No. The heart is divided into two cavities or compartitions, called the *right* and *left ventricles.* The left ventricle is the recepticle for the pure arterial blood previous to its circulation; whilst the venous, or impure blood, which returns to the heart after having circulated, is received into the right ventricle, previous to its purification, which I shall presently explain.

Caroline. For my part, I always thought that the same blood circulated again and again through the body, without undergoing any change.

Mrs. B. Yet you must have supposed that the blood circulated for some purpose?

Caroline. I knew that it was indispensable to life, but had no idea of its real functions.

Mrs. B. But now that you understand that the blood conveys nourishment to every part of the body, and supplies the various secretions, you must be sensible that it cannot constantly answer these objects without being renovated and purified.

Caroline. But does not the chyle answer this purpose?

Mrs. B. Only in part. It renovates the nutritive principles of the blood, but does not relieve it from the superabundance of hydrogen and carbone with which it is incumbered.

Emily. How then is this effected?

Mrs. B. By RESPIRATION. This is one of the grand mysteries which modern chemistry has disclosed. When the venous blood enters the left ventricle of the heart, it contracts by its muscular power, and throws the blood through a large vessel into the lungs, which are contiguous, and through which it circulates by millions of small ramifications. Here it comes in contact with the air which we breathe. The action of the air on the blood in the lungs is indeed concealed from our immediate observation; but we are able to form a tolerably accurate judgment of it from the changes which it effects not only in the blood, but also on the air expired.

This air is found to contain all the nitrogen inspired, but to have lost part of its oxygen, and to have acquired a portion of watery vapour. Hence it is inferred, that when the air comes in contact with the venous blood in the lungs, the oxygen attracts from it the superabundant quantity of hydrogen and carbone with which it has impregnated itself during the circulation; and that one part of that oxygen combines with the hydrogen, in the form of watery vapour, whilst another part combines with the carbone, which it converts into carbonic acid. The whole of these products being then expired, the blood is restored to its former purity, that is, to the state of arterial blood, and is thus again enabled to perform its various functions.

Caroline. This is truly wonderful! Of all that we have yet learned, I do not recollect any thing that has appeared to me so curious and interesting. I almost believe that I should like to study anatomy now, though I have hitherto had so disgusting an idea of it. Pray to whom are we indebted for these beautiful discoveries?

Mrs. B. Crawford, in this country, and Lavoisier in France, are the principal inventors of the theory of respiration. But the still more important and more admirable discovery of the circulation of the blood was made long before by our immortal countryman, Hervey.

Emily. Indeed I never heard any thing that delighted me so much as this theory of respiration. But I hope, Mrs. B. that you will enter a little more into particulars before you dismiss so interesting a subject. We left the blood in the lungs to undergo the salutary change. But how does it thence spread to all the parts of the body?

Mrs. B. After circulating through the lungs, the blood is collected into four large vessels, by which it is conveyed into the left ventricle of the heart, whence it is propelled to all the different parts of the body by a large artery which gradually ramifies into millions of small arteries through the whole frame. From the extremities of these little ramifications the blood is transmitted to the veins, which bring it back to the heart

and lungs, to go round again and again in the manner we have just described. You see, therefore, that the blood actually undergoes two circulations; the one, through the lungs, by which it is converted into pure arterial blood; the other, or general circulation, by which nourishment is conveyed to every part of the body; and these are both equally indispensable to the support of animal life.

Caroline. Do we expire all the air that we inspire, besides the addition of hydrogen and carbone which are taken up from the blood?

Mrs. B. Yes, excepting small portions of the oxygen, and of the nytrogen, which, as they do not reappear, are supposed to be absorbed by the blood for some purposes which have not yet been clearly ascertained. The general opinion, however, with regard to oxygen, is, that it serves to stimulate the heart and keep up its muscular action. As to the nitrogen, it was supposed to be expired from the lungs, without any change or diminution. But it was proved a few years ago, by some of Mr. Davy's experiments, which have been since confirmed by those of professor Pfaff of Kiel, that a small quantity of nitrogen disappears in respiration, and combines with the system in a manner which is not yet well understood.

Emily. But whence proceeds the hydrogen and carbone with which the blood is impregnated when it comes into the lungs?

Mrs. B. Both hydrogen and carbone exist in a greater proportion in blood than in organized animal matter. The blood, therefore, after supplying its various secretions, becomes loaded with an excess of these principles, which is carried off by respiration. But, besides this, the formation of new chyle affords a constant supply of carbone and hydrogen.

Caroline. Pray, how does the air come in contact with the blood in the lungs?

Mrs. B. I cannot answer this question without entering into an explanation of the nature and structure of the lungs. You recollect that the venous blood on being expelled from the right ventricle, enters the

lungs to go through what we may call the les: lation; the large trunk or vessel that conveys ches out, at its entrance into the lungs, into a number of very fine ramifications.—The \ which conveys the air from the mouth into tl likewise spreads out into a corresponding nu air vessels, which follow the same course as t vessels, forming millions of very minute air These two setts of vessels are so interwoven as a sort of net-work, connected into a kind of mass, in which every particle of blood must nec come in contact with a particle of air.

Caroline. But since the blood and the air ; tained in different vessels, how can they come i tact?

Mrs. B. They act on each other through the brane which forms the coats of these vessels; though this membrane prevents the blood and i from mixing together in the lungs, yet it is no ir ment to their chemical action on each other.

Emily. Are the lungs composed entirely of vessels and air vessels?

Mrs. B. I believe they are with the additio of nerves and of a small quantity of the celluk stance before mentioned, which connects the wh to an uniform mass.

Emily. Pray, why are the lungs always spc in the plural number? is there more than one?

Mrs. B. Yes; for though they form but one they really consist of two compartments calle which are enclosed in separate membranes o each occupying one side of the chest, and being contact with each other, but without commu together. This is a beautiful provision of na consequence of which, if one of the lobes be w the other performs the whole process of respir the first is healed.

But, before we proceed further, I must info that the chemical theory of respiration, witl you have just been made acquainted, simple ar tiful as it is, has appeared to many philosphe

ient to explain all the phenomena of respiration. nongst the various modifications proposed, with a w to improve this theory, that suggested by La ange, Hassenfratz, and some other eminent chem-, appears to be the most important. These philos-hers suppose that the oxygen, which disappears in spiration, is absorbed by the blood, and carried with into the circulation, during which it gradually com-nes with the hydrogen and carbone that are succes-vely added to the circulation, forming the water and rbonic acid which are expelled from the lungs at each piration. Thus the process, instead of being com-eted in the lungs, as the former theory supposes, on-begins in that organ, and cotninues throughout the culation.

According to this theory, the florid colour of arterial od depends upon the addition of oxygen, so that this our gradually vanishes as the blood passes from the rial to the venous state, that is to say, as the oxygen ers into combination with the hydrogen and carbone ing circulation.

Caroline. There does not appear to me to be any y essential difference in these two theories, since both the oxygen purifies the blood by combining with carrying off the matter which had accumulated in uring circulation.

Mrs. B. Yes; but, in medical, or rather phisio-gical science, it must be a question of great impor-nce, whether the oxygen actually enters the circula-n, or whether it proceeds no further than the lungs.

The blood thus completed, forms the most com-ex of all animal compounds, since it contains not on-the numerous materials necessary to form the various cretions, as saliva, tears, &c. but likewise all those at are required to nourish the several parts of the ame, as the muscles, bones, nerves, glands, &c.

Emily. There seems to be a singular analogy be-een the blood of animals, and the sap of vegetables; r each of these fluids contain the several materials estined for the nutrition of the numerous class of bo-ies to which they respectively belong.

Mrs. B. Nor is the production of these flui
the animal and vegetable systems entirely differ
for the absorbent vessels, which pump up the e
from the stomach and intestines, may be compar
the absorbents of the roots of plants, which suc
the nourishment from the soil. And the analogy
tween the sap and the blood may be still further tr
if we follow the latter in the course of its circulat
for in the living animal, we find every where or
which are possessed of a power to secrete from
blood and appropriate to themselves the ingredient
quisite for their support.

Caroline. But whence does these organs derive t
respective powers ?

Mrs. B. From peculiar organization, the secre
which no one has yet ever been able to unfold. B
must be ultimately by means of the vital principle t
both their mechanical and chemical powers are brou
into action.

I cannot dismiss the subject of circulation with
mentioning *perspiration*, a secretion which is imme
ately connected with it, and acts a most important p
in the animal economy.

Caroline. Is not this secretion likewise made by
propriate glands ?

Mrs. B. No ; it is performed by the extremitie
the arteries, which penetrate through the skin and
minate under the cuticle, through the pores of w
the perspiration issues. When this fluid is not sec
ed in excess, it is *insensible*, because it is dissolved
the air as it exudes from the pores : but when it is
creted faster than it can be dissolved, it becomes *se
ble*, as it assumes its liquid state.

Emily. This secretion bears a striking resembl
to the transpiration of the sap of plants. They
consist of the most fluid parts, and both exude f
the surface by the extremities of the vessels thro
which they circulate.

Mrs. B. And the analogy does not stop there ;
since it has been ascertained that the sap returns
the roots of the plants, the resemblance betwee

l and vegetable circulation is become still more ıs. The latter, however, is far from being com- since, as we observed before, it consists only sing and descending of the sap, whilst in animals lood actually *circulates* through every part of the n.

: have now, I think, traced the process of nutri- om the introduction of the food into the stomach finally becoming a constituent part of the animal . This will, therefore, be a fit period to conclude esent conversation. What further remarks we o make on the animal economy shall be reserved r next interview.

Conversation XXIII.

ı *Animal Heat: and on various Animal Products.*

Emily.

ICE our last interview, I have been thinking much e theory of respiration ; and I cannot help being k with the resemblance which it appears to bear : process of combustion. For in respiration, as in cases of combustion, the air suffers a change, and tion of its oxygen combines with hydrogen and ne, producing carbonic acid and water.

rs. B. I am much pleased that this idea has oc- d to you : these two processes appear so very anal- s, that it has been supposed that a kind of com- on actually takes place in the lungs ; not of the , but of the superfluous hydrogen and carbone ı the oxygen attracts from it.

Caroline. A combustion in our lungs! that is a ous idea indeed! But, Mrs. B. how can you c action of the air on the blood in the lungs, combu when neither light nor heat are produced by it?

Emily. I was going to make the same obje Yet I do not conceive how the oxygen can combine the hydrogen and carbone, and produce water an bonic acid, without disengaging heat?

Mrs. B. The fact is, that heat is diseng Whether any light be evolved, I cannot pretend t termine; but that heat is produced in considerabl very sensible quantities is certain, and this is the pal, if not the only source of ANIMAL HEAT.

Emily. How wonderful! that the very process purifies and elaborates the blood, should afford a exhaustible supply of internal heat!

Mrs. B. This is the theory of animal heat original simplicity, such as it was first proposed by and Lavoisier. It is equally clear and ingenious was at first generally adopted. But it was o ed, on second consideration, that if the whole o animal heat was evolved in the lungs, it would n sarily be much less in the extremities of the body, immediately at its source; which is not found to b case. This objection, however, which was by no m frivolous, is now satisfactorily answered by mea the improved theory of respiration which I menti last. According to this hypothesis, you recollect, changes which the blood undergoes in consequen respiration only begin in the lungs and gradually tinue during circulation. Therefore the animal h which is the consequence of those changes, like begins in the lungs, and afterwards continues du the whole circulation; and heat is thus uniformly fused throughout every part of the body.

Caroline. More and more admirable!

Mrs. B. Now let me hear whether you can exp how animal heat is produced. You, Caroline, tell in what manner it is first evolved in the lungs?

Caroline. Part of the oxygen gas inspired, imm diately combines in the lungs with the loose car

rogen of the venous blood; and the caloric evolv-
ıg this combination, becomes animal heat.

B. Very well; but you must observe, that
ıle of the oxygen inspired at a breath is not con-
by one respiration: a considerable part of it is
, so that we may breathe the same portion of
ral times before the whole of the oxygen is ex-
—Now, Emily, will you explain to me in what
an uniform degree of heat is kept up through-
body?

/. A quantity of oxygen enters into the circu-
ıring which it gradually combines with the hy-
and carbone of the blood, thus producing a con-
sengagement of heat throughout every part of
y.

B. Very well, indeed. You have in a few
stated nearly all that can be said on the subject.
however, mention another circumstance which
ıtribute to account for the gradual evolution of
ıeat. It appears, from some experiments, that
d, in consequence of the successive changes it
ɔes during circulation (by which it is gradually
ed from arterial into venous blood), has its ca-
ɔr caloric diminished. What must be the con-
.e of this?

/. That heat, of course, must be disengaged.

B. Exactly so; and thus an additional quan-
nimal heat must be generated. However, the
ɔduced in this way is but trifling, and could on-
ınt for a very small portion of the animal tem-
e.

ine. The cause of animal heat was always a
mystery to me, and I am delighted with its ex-
n.—But pray, Mrs. B. can you tell me what is
on of the increase of heat that takes place in a

. Is it not because we then breathe quicker, and
'e more heat is disengaged in the system?

B. That may be one reason: but I should think
principal cause of the heat experienced in fe-
, that there is no vent for the caloric which is

generated in the body. One of the most considerable secretions is the insensible perspiration; this is constantly carrying off caloric in a latent state; but during the hot stage of a fever, the pores are so contracted that all perspiration ceases, and the accumulation of caloric in the body occasions those burning sensations that are so painful.

Emily. This is, no doubt, the reason why the perspiration that often succeeds the hot stage of a fever affords so much relief. If I had known this theory of animal heat when I had a fever last summer, I think I should have found some amusement in watching the chemical processes that were going on within me.

Caroline. But exercise likewise produces animal heat, and that must be quite in a different manner.

Mrs. B. Not so much so as you think; for the more exercise you take, the more the body is stimulated, and requires recruiting. For this purpose the circulation of the blood is quickened, the breath proportionably accelerated, and consequently a greater quantity of caloric evolved.

Caroline. True; after running very fast, I gasp for breath, my respiration is quick and hard, and it is just then that I begin to feel hot.

Emily. It would seem, then, that violent exercise should produce fever.

Mrs. B. Not if the person is in a good state of health; for the additional caloric is then carried off by the perspiration which succeeds.

Emily. What admirable resources nature has provided for us! By the production of animal heat she has enabled us to keep up the temperature of our bodies above that of inanimate objects; and whenever this source becomes too abundant, the excess is carried off by perspiration.

Mrs. B. It is by the same law of nature that we are enabled, in all climates, and in all seasons, to preserve our bodies of an equal temperature, or at least very nearly so.

Caroline. You cannot mean to say that our bodies are of the same temperature in summer and in winter, in England and in the West Indies?

- *B.* Yes, I do; at least if you speak of the tem-
-e of the blood, and the internal parts of the body;
se parts that are immediately in contact with the
here, such as the hands and face, will occasionally
rmer, or colder, than the internal or more shel-
arts. But if you put the bulb of a thermometer
mouth, which is the best way of ascertaining the
mperature of your body, you will scarcely per-
ny difference in its indication, whatever may be
erence of temperature of the atmosphere.

line. And when I feel overcome by heat, I am
ot hotter than when I am shivering with cold?

B. When a person in health feels very hot,
r from internal heat, from violent exercise, or
e temperature of the atmosphere, his body is
y a little warmer than when he feels very cold;
s difference is much smaller than our sensations
nake us believe; and the natural standard is soon
d by rest and perspiration. I am sure you will
prised to hear that the internal temperature of
dy scarcely ever descends below 95° or 96°, and
ever attains 104° or 105°, even in the most vio-
vers.

ly. The greater quantity of caloric, therefore,
e receive from the atmosphere in summer, cannot
the temperature of our bodies, beyond certain
as it does that of inanimate bodies, because an
of caloric is carried off by perspiration.

oline. But the temperature of the atmosphere,
nsequently that of inanimate bodies, is surely nev-
igh as that of animal heat?

, B. I beg your pardon. Frequently in the East
Vest Indies, and sometimes, in the southern parts
rope, the atmosphere is above 98°, which is the
on temperature of animal heat.—Indeed, even in
untry, it occasionally happens that the sun's rays,
full on an object, elevate its temperature above
oint.

llustration of the power which our bodies have to
the effects of external heat, Sir Charles Blagden,
ome other gentlemen, made several very curious
ments. He remained for some time in an oven

heated to a temperature not much inferior to that of boiling water, without suffering any other inconvenience than a profuse perspiration, which he supported by drinking plentifully.

Emily. He could scarcely consider the perspiration as an inconvenience, since it saved him from being baked, by giving vent to the exess of caloric.

Caroline. I always thought, I confess, that it was from the heat of the perspiration that we suffered in summer.

Mrs. B. You now find that you were quite mistaken. Whenever evaporation takes place, cold, you know, is produced in consequence of a quantity of caloric being carried off in a latent state; this is the case with perspiration, and it is in this way that it affords relief. It is for the same reason that tea is often refreshing in summer, though it appears to heat you at the moment you drink it.

Emily. And in winter, on the contrary, tea is pleasant on account of its heat.

Mrs. B. Yes; for we have then rather to guard against a deficiency than an excess of caloric, and you do not find that tea will excite perspiration in winter, unless after dancing, or any other violent exercise.

Caroline. What is the reason that it is dangerous to eat ice after dancing, or to drink any thing cold when one is very hot?

Mrs. B. Because the loss of heat arising from the perspiration, conjointly with the chill occasioned by the cold draught, produces more cold than can be borne with safety, unless you continue to use the same exercise after drinking that you did before; for the heat occasioned by the exercise will counteract the effects of the cold drink, and the danger will be removed. You may, however, contrary to the common notion, consider it as a rule, that cold liquids may at all times, be drunk with perfect safety, however hot you may feel, provided you are not at the moment in a state of great perspiration, and on condition that you keep yourself in gentle exercise afterwards.

Emily. But since we are furnished with such resources against the extremes of heat or cold, I should

thought that all climates would have been equally
esome.

s. B. That is true, in a certain degree, with re-
to those who have been accustomed to them from
; for we find that the natives of those climates,
h we consider as the most deleterious, are as heal-
s ourselves; and if such climates are unwholesome
se who are habituated to a more moderate tempe-
e, it is because the animal economy does not easily
tom itself to considerable changes.

oline. But pray, Mrs. B. if the circulation pre-
s the body of an uniform temperature, how does it
en, that animals are sometimes frozen?

s. B. Because if more heat is carried off by the
sphere than the circulation can supply, the cold
ally prevail, the heart will cease to beat, and the
l will be frozen. And likewise, if the body re-
ed long exposed to a degree of heat, greater than
erspiration could carry off, it would at last lose the
r of resisting its destructive influence.

oline. Fish, I suppose, have no animal heat, but
ke of the temperature of inanimate objects?

ily. And their coldness, no doubt, proceeds from
not breathing?

s. B. All kinds of fish, I believe, breathe more
s, though in a much smaller degree than land ani-
. Nor are they entirely destitute of animal heat,
gh for the same reason they are much colder than
creatures. They have comparatively but a very
quantity of blood, therefore but little oxygen is re-
d, and a proportionally small quantity of animal
is generated.

roline. But how can fish breathe under water?

rs. B. Some of them raise their heads above the
r to breathe; and others are supposed to be endow-
nature with the power of decomposing water and
bing oxygen from it. Besides, water always con-
air mixed with it, which the fish may possibly ap-
o the purposes of respiration. Whatever the case
be, it is certain that several kinds of fish have re-
irs of air, or air bags, from which they have prob-

ably the means of supplying the gills, an organ which, in the respiration of fish, answers the double purpose of mouth and lungs.

Caroline. Are there any species of animals that breathe more than we do?

Mrs. B. Yes; birds, of all animals, breathe the greatest quantity of air in proportion to their size; and it is to this that they are supposed to owe the peculiar firmness and strength of their muscles, by which they are enabled to support the violent exertion of flying.

This difference between birds and fish, which may be considered as the two extremes of the scale of muscular strength, is well worth observing. Birds residing constantly in the atmosphere, surrounded by oxygen, and respiring it in greater proportions than any other species of animals, are endowed with a superior degree of muscular strength, whilst the muscles of fish, on the contrary, are flaccid and oily; these animals are comparitively slow and feeble in their motions, and their temperature is scarcely above that of the water in which they live. This is, in all probability, owing to their imperfect respiration; the quantity of hydrogen and carbone, that is in consequence accumulated in their bodies, forms the oil which is so strongly characteristic of that species of animals, and which relaxes and softens the small quantity of fibrine which their muscles contain.

Caroline. But, Mrs. B. there are some species of birds that frequent both elements, as, for instance, ducks and other water fowl. Of what nature is the flesh of these?

Mrs. B. Such birds, in general, make but little use of their wings; if they fly, it is but feebly, and only to a short distance. Their flesh too partakes of the oily nature, and even in taste sometimes resembles that of fish. This is the case not only with the various kinds of water fowls, but with all other amphibious animals, as the otter, the crocodile, the lizard, &c.

Caroline. And what is the reason that reptiles are so deficient in muscular strength?

Mrs. B. It is because they usually live under ground, and seldom come into the atmosphere.—The

ve imperfect, and sometimes no discernible organs respiration, they partake therefore of the soft oily ture of fish; indeed, many of them are amphibious, frogs, toads, and snakes, and very few of them find y difficulty in remaining a length of time under wa-. Whilst, on the contrary, the insect tribe that are strong in proportion to their size, and alert in their tions, partake of the nature of birds, air being their culiar element, and their organs of respiration being mparatively larger than in other classes of animals.

I have now given you a short account of the princi- animal functions. However interesting the subject y appear to you, a fuller investigation of it would, ear, lead us too far from our object.

Emily. Yet I shall not quit it without much regret; of all the branches of chemistry, it is certainly the st curious and most interesting.

Caroline. But, Mrs. B. I must remind you that promised to give us some account of the nature of k.

Mrs. B. True. There are several other animal ductions that deserve likewise to be mentioned. We ll begin with milk, which is certainly the most im- tant and most interesting of all the animal secretions.

Milk, like all other animal substances, ultimately lds by analysis, oxygen, hydrogen, carbone, and rogen. These are combined in it under the forms albumen, gelatine, oil, and water. But milk con- ns, besides, a considerable portion of phosphat of ne, the purposes of which, I have already pointed .

Caroline. Yes; it is the salt which serves to nou- the tender bones of the suckling?

Mrs. B. To reduce milk to its elements would be ery complicated, as well as useless operation; but fluid, without any chemical assistance, may be de- nposed into three parts, *cream*, *curds*, and *whey*.— ese constituents of milk have but a very slight affin- to each other, and you find accordingly that cream arates from milk by mere standing. It consists efly of oil, which being lighter than the other parts

of the milk, gradually rises to the surface. It is of thi you know, that butter is made, which is nothing mo than oxygenated cream.

Caroline. Butter, then, is somewhat analogous the waxy substance formed by the oxygenation of ve ctable oils.

Mrs. B. Very much so.

Emily. But is the cream oxygenated by churning

Mrs. B. Its oxygenation commences previous churning, merely by standing exposed to the atmo phere, from which it absorbs oxygen. The proce is afterwards completed by churning; the violent m tion which this operation occasions, brings every pa ticle of cream in contact with the atmosphere, a thus facilitates its oxygenation.

Caroline. But the effect of churning, I have of observed in the dairy, is to separate the cream i two substances, butter, and butter-milk?

Mrs. B. That is to say, in proportion as the o particles of the cream become oxygenated, they se rate from the other constituent parts of the cream the form of butter. So by churning you produce, the one hand, butter, or oxygenated oil; and, on other, butter-milk, or cream deprived of oil.—Bu you make butter by churning new milk instead of cre the butter-milk will then be exactly similar in its p perties to creamed or skimmed milk.

Caroline. Yet butter-milk is very different fr common skimmed milk.

Mrs. B. Because you know it is customary, order to save time and labour, to make butter fr cream alone. In this case, therefore, the butter-m is deprived of the creamed milk, which contains the curd and the whey. Besides, in consequence the milk remaining exposed to the atmosphere du the separation of the cream, the latter becomes m or less acid, as well as the butter-milk which it yi in churning.

Emily. Why should not the butter be equally ac fied by oxygenation?

Mrs. B. Animal oil is not so easily acidified a

ingredients of milk. Butter, therefore, though ly made of sour cream, is not sour itself, because ly part of the cream had not been acidified. But-however, is susceptible of becoming acid by an ss of oxygen; it is then said to be rancid, and pro-s the sebacic acid, the same which is obtained fat.

mily. If that be the case, might not rancid butter weetened by mixing with it some substance that d take the acid from it?

rs. B. This idea has been suggested by Mr. Da-who supposes, that if rancid butter were well wash-an alkaline solution, the alkali would separate the from the butter.

roline. You said just now that creamed milk con-d of curd and whey. Pray how are these separa-

rs. B. They may be separated by standing for a in length of time exposed to the atmosphere; but decomposition may be almost instantaneously ef-d by the chemical agency of a variety of substan-Alkalies, rennet,* and indeed almost all animal tances, decompose milk by combining with the s.

cids and spirituous liquors, on the other hand, pro-a decomposition by combining with the whey. In r therefore to obtain the whey pure, rennet, or line substances, must be used to attract the curds n it.

ut if it be wished to obtain the curds pure, the y must be separated by acids, wine, or other spi-ous liquors.

mily. This is a very useful piece of information; I find white wine whey, which I sometimes take n I have a cold, extremely heating; now, if the y were separated by means of an alkali instead of e, it could not produce that effect.

* *Rennet is the name given to a watery infusion of the of the stomach of a sucking calf. Its remarkable ef-y in promoting coagulation is supposed to depend on astric juice with which it is impregnated.*

Mrs. B. Perhaps not. But I would strenuo
vise you not to place too much reliance on you
chemical knowledge in medical matters. I do no
why whey is not separated from curd by rennet
an alkali, for the purpose which you mentio
strongly suspect there must be some good rea
the preparation by means of wine is generally
red. I can, however, safely point out to you a
of obtaining whey without either alkali, ren
wine; it is by substituting lemon juice, a very
quantity of which will separate it from the curd

Whey, as an article of diet, is very wholeso
is the most nutritive part of the milk, and the
of digestion. But its effect, taken medicinally,
ly, I believe, to excite perspiration, by being
warm on going to bed.

It appears that the nutritive particles of whey
obtained in crystals by evaporation; in this sta
are called salts, or more commonly *sugar of mil*
salt is sweet to the taste, and in its compositio
analogous to sugar, that it is susceptible of und
the vinous fermentation.

Caroline. Why then is not wine, or alcoho
from whey?

Mrs. B. The quantity of sugar contained
is so trifling that it can hardly answer for that p
I have heard of only one instance of its being
the production of a spirituous liquor, and th
the Arabs; their abundance of horses as well
scarcity of fruits, has introduced the ferment
mares' milk, by which they produce a liquo
koumiss. Whey is likewise susceptible of bei
fied by combining with oxygen from the atmo
It then produces the *lactic acid*, which you ma
lect is mentioned amongst the animal acids, as
of milk.

Let us now see what are the properties of c

Emily. I know that they are made into che
I have heard that for that purpose they are s
from the whey by rennet, and yet this you have
us is not the method of obtaining pure curds?

Mrs. B. Nor are pure curds so well adapte

nation of cheese. For the nature and flavour of the ese depends, in a great measure, upon the cream ily matter which is left in the curds; so that if eve- particle of cream be removed from the curds, the ese is scarcely eatable. Rich cheeses, such as im and Stilton cheeses, derive their excellence from quantity, as well as the quality of the cream that ers into their composition.

Caroline. I had no idea that milk was such an inter- ng compound. In many respects there appears to to be a very striking analogy between milk and the tents of an egg, both in respect to their nature and ir use. They are, each of them, composed of the ious substances necessary for the nourishment of the ng animal, and equally destined for that purpose.

Mrs. B. There is, however, a very essential dif- nce. The young animal is formed, as well as nour- d by the contents of the egg-shell; whilst milk es as nutriment to the suckling, only after it is born. 'here are several peculiar animal substances which not enter into the general enumeration of animal pounds, and which, however, deserve to be men- ed.

ermaceti is of this class; it is a kind of oily sub- e obtained from the head of the whale, which, ever, must undergo a certain preparation before it a fit state to be made into candles. It is not much e combustible than tallow, but it is more pleasant to , as it is less fusible and less greasy.

nbergris is another peculiar substance derived from ecies of whale. It is, however, seldom obtained the animal itself, but is generally found floating he surface of the sea.

Wax, you know, is a concrete oil, the peculiar pro- of the bee, part of the constituents of which may ably be derived from flowers, but so prepared by organs of the bee, and so mixed with its own sub- ce, as to be decidedly an animal product. Bees'- is naturally of a yellow colour, but it is bleached ong exposure to the atmosphere, or may be instan- ously whitened by the oxy-muriatic acid. The ibustion of wax is far more perfect than that of tal-

low, and consequently produces a greater quanti light and heat.

Lac is a substance very similar to wax in the ner of its formation; it is the product of an insect collects its ingredients from flowers, apparently f purpose of protecting its eggs from injury. It is ed into cells fabricated with as much skill as th the honey-comb, but differently arranged. The cipal use of lac is in the manufacture of sealing and in dying scarlet.

Musk, *civet*, and *castor*, are other particular p tions, from different species of quadrupeds. Th first are very powerful perfumes; the latter has seous smell and taste, and is only used medicina

Caroline. Is it from this substance that casto obtained?

Mrs. B. No. Far from it, for castor oil is a able oil, expressed from the seeds of a particular and has not the least resemblance to the medicin stance obtained from the castor.

Silk is a peculiar secretion of the silk worm which it builds its nest or cocoon. This inse originally brought to Europe from China. Silk chemical nature, is very similar to the hair and animals. The moth of the silk worm ejects a which appears to contain a particular acid, calle *bic*, the properties of which are very little known

Emily. Before we conclude the subject of t mal economy, shall we not learn by what steps a return to their elementary state?

Mrs. B. Animal matter, although the mos plicated of all natural substances, returns to its el tary state by one single spontaneous process, the *fermentation*. By this, the gelatine, albumen, brine, are slowly reduced to the state of oxyge drogen, nitrogen, and carbone; and thus the ci changes through which these principles have is finally completed. They first quitted their el tary form, or their combination with unorganize ter, to enter into the vegetable system.—Henc were transmitted to the animal kingdom; and

this they return again to their primitive simplicity, soon to re-enter the sphere of organized existence.

When all the circumstances necessary to produce fermentation do not take place, animal, like vegetable matter, is liable to a partial or imperfect decomposition, which converts it into a combustible substance very like spermaceti. I dare say that Caroline, who is so fond of analogies, will consider this as a kind of animal bitumen.

Caroline. And why should I not, since the processes, that produce these substances are so similar.

Mrs. B. There is, however, one considerable difference; the state of bitumen seems permanent, whilst that of animal substances, thus imperfectly decomposed, is only transient; and, unless precautions be taken to preserve them in that state, a total dissolution infallibly ensues. This circumstance, of the occasional conversion of animal matter into a kind of spermaceti, is of late discovery. A manufacture has in consequence been established near Bristol, in which, by exposing the carcases of horses and other animals for a length of time under water, the muscular parts are converted into this spermaceti-like substance. The bones afterwards undergo a different process to produce hartshorn, or, more properly, ammonia, and phosphorous; and the skin is prepared for leather.

Thus art contrives to enlarge the sphere of useful purposes, to which the elements were intended by nature; and the productions of the several kingdoms are frequently arrested in their course, and variously modified, by human skill, which compels them to contribute, under new forms, to the necessities or luxuries of man.

But all that we enjoy, whether produced by the spontaneous operations of nature, or the ingenious efforts of art, proceed alike from the goodness of Providence.—To GOD alone man owes the admirable faculties which enable him to improve and modify the productions of nature, no less than those productions themselves. In contemplating the works of the creation, or studying the inventions of art, let us, therefore, never forget the Divine Source from which they proceed; and thus every acquisition of knowledge will prove a lesson of piety and virtue.

END OF THE LONDON COPY.

An abridgement of the Bakerian Lecture on the decomposition of the fixed alkalies and the exhibition of the new substances which constitute their bases: by Humphry Davy, esq. secretary of the Royal Society.

The researches I had made on the decomposition of acids, and of alkaline and earthly neutral compounds, proved that the powers of electrical decomposition were proportional to the strength of the opposite electricities in the circuit, and to the conducting power and degree of concentration of the materials employed. In the first attempts I made on the decomposition of the fixed alkalies, I acted upon aqueous solutions of potash and soda, saturated at common temperatures, by the highest electrical power I could command, and which was produced by a combination of voltaic batteries, belonging to the Royal Institution, containing 24 plates of copper and zinc of 12 inches square, 100 plates of 6 inches, and 150 of 4 inches square, charged with solutions of alum and nitrous acid; but in these cases, though there was a high intensity of action, the water of the solutions alone was effected, and hydrogen and oxygen disengaged with the production of much heat and violent effervescence. The presence of water appearing thus to prevent any decomposition, I used potash in igneous fusion. By means of a stream of oxygen gas from a gasometer applied to the flame of a spirit lamp, which was thrown on a platina spoon containing potash, this alkali was kept for some minutes in a strong red heat, and in a state of perfect fluidity. The spoon was preserved in communication with the positive side of the battery, of the power of 100 of 6 inches, highly charged; and the connection from the negative side was made by a platina wire. By this arrangement some brilliant phenomena were produced. The potash appeared a conductor, in a high degree, and as long as the communication was preserved, a most intense light was exhibited at the negative wire, and a column of flame, which seemed to be owing to the development of combustible matter, arose from the point of contact. When the order was changed, so that the platina spoon was made negative, a vivid, constant light

ared at the opposite point. There was no effect flammation round it, but æriform globules, which med in the atmosphere, rose through the potash. platina, as might have been expected, was con-ably acted upon; and in the cases when it had negative in the highest degree.

he alkali was apparently dry in this experiment; it seemed probable, that the inflammable matter from its decomposition. The residual potash unaltered; it contained, indeed, a number of dark metallic particles, but these proved to be derived the platina.

tried several experiments on the electrization of sh, rendered fluid by heat, with the hopes of being to collect the combustible matter, but without suc-; and I only attained my object, by employing tricity, as the common agent for fusion and decom-tion. Though potash, perfectly dried by ignition, non-conductor, yet it is rendered a conductor by a slight addition of moisture, which does not per-ibly destroy its aggregation; and in this state it ily fuses and decomposes by strong electrical pow-

small piece of pure potash, which had qeen ex-d for a few seconds to the atmosphere, so as to give lucting power to the surface, was placed upon an lated disc of platina, connected with the negative of the battery, of the power of two hundred and of six and four, in a state of intense activity; and tina wire, communicating with the positive side, was ght in contact with the upper surface of the alka-The whole apparatus was in the open atmosphere.

nder these circumstances, a vivid action was soon rved to take place. The potash began to fuse at its points of electrization. There was a violent rvescence at the upper surface: at the lower or ative surface, there was no liberation of elastic flu-but small globules, having a high metallic lustre, being precisely similar, in visible characters to cksilver, appeared; some of which burnt with ex-sion, and bright flame, as soon as they were form-others remained, and were merely tarnished, and

finally covered by a white film, which formed on their surfaces. These globules, numerous experiments soon showed to be the substance I was in search of, and a peculiar inflammable principle the basis of potash. I found that the platina was in no way connected with the result, except as the medium for exhibiting the electrical powers of decomposition; and a substance of the same kind was produced, when pieces of copper, silver, gold, plumbago, and even charcoal were employed for completing the circuit. The phenomenon was independent of the presence of air. I found that it took place when the alkali was in the vacuum of an exhausted receiver. The substance was likewise produced from potash fused by means of a lamp, in glass tubes confined by mercury, and furnished with hermetically inserted platina wires, by which the electrical action was transmitted. But this operation could not be carried on for any considerable time; the glass was rapidly dissolved by the action of the alkali, and this substance soon penetrated through the body of the tube.

Soda, when acted upon in the same manner as potash, exhibited an analogous result; but the decomposition demanded greater intensity of action in the batteries, or the alkali was required to be in much thinner and smaller pieces. With the battery of one hundred of six inches in full activity, I obtained good results from pieces of potash weighing from forty to seventy grains, and of a thickness which made the distance of the electrified metallic surfaces nearly a quarter of an inch; but with a similar power it was impossible to produce the effects of decomposition on pieces of soda of more than fifteen and twenty grains in weight, and that only when the distance between the wires was about one eighth or one tenth of an inch.

The substance produced from potash remained fluid at the temperature of the atmosphere at the time of its production; that from soda, which was fluid in the degree of heat of the alkali during its formation, became solid on cooling, and appeared having the lustre of silver.

When the power of two hundred and fifty was used with a very high charge for the decomposition of soda

the globules often burnt at the moment of their formation, and sometimes violently exploded and separated into smaller globules, which flew with great velocity through the air, in a state of vivid combustion, producing a beautiful effect of continued jets of fire.

III. *Theory of the Decomposition of the fixed Alkalies; their Composition and Production.*

As in all decompositions of compound substances which I had previously examined, at the same time that combustible bases were developed at the negative surface in the electrical circuit, oxygen was produced, and evolved or carried into combination at the positive surface; it was reasonable to conclude that this substance was generated in a similar manner by the electrical action upon the alkalies, and a number of experiments made above mercury, with the apparatus for excluding external air, proved that this was the case.

When solid potash, or soda in its conducting state, was included in glass tubes, furnished with electrified platina wires, the new substances were generated at the negative surfaces; the gas given out at the other surface proved, by the most delicate examination, to be pure oxygen; and unless an excess of water was present, no gas was evolved from the negative surface.

In the synthetical experiments, a perfect coincidence likewise will be found.

I mentioned that the metallic lustre of the substance from potash immediately became destroyed in the atmosphere, and that a white crust formed upon it. This crust I soon found to be pure potash, which immediately deliquesced, and new quantities were formed, which in their turn attracted moisture from the atmosphere, till the whole globule disappeared, and assumed the form of a saturated solution of potash.

When globules were placed in appropriate tubes, containing common air or oxygen gas, confined by mercury, an absorption of oxygen took place; a crust of alkali instantly formed upon the globule; but from

the want of moisture for its solution the process stopped, the interior being defended from the action of the gas.

With the substances from soda the appearances and effects were analogous. When the substances were strongly heated, confined in given portions of oxygen, a rapid combustion with a brilliant white flame was produced, and the metallic globules were found converted into a white and solid mass, which, in the case of the substance from potash, was found to be potash, and in the case of that from soda, soda.

Oxygen gas was absorbed in this operation, and nothing emitted which effected the purity of the residual air. The alkalies produced were apparently dry, or at least contained no more moisture than might well be conceived to exist in the oxygen gas absorbed; and their weights considerably exceeded those of the combustible matters consumed. The processes on which these conclusions are founded will be fully described hereafter, when the minute details which are necessary will be explained, and the proportions of oxygen and of the respective inflammable substances which enter into union to form the fixed alkalies will be given.

It appears, then, that in these facts there is the same evidence for the decomposition of potash and soda into oxygen and two peculiar substances, as there is for the decomposition of sulphuric and phosphoric acids and the metallic oxyds into oxygen and their respective combustible bases.

In the analytical experiments, no substances capable of decomposition are present, but the alkalies and a minute portion of moisture; which seems in no other way essential to the result, than in rendering them conductors at the surface: for the new substances are not generated till the interior, which is dry, begins to be fused; they explode when in rising through the fused alkali; they come in contact with the heated moistened surface; they cannot be produced from crystallized alkalies, which contain much water; and the effects produced by the electrization of ignited potash which contains no sensible quantity of water, confirm the opinion of their formation independently of the presence of this substance.

The combustible bases of the fixed alkalies seem to repelled as other combustible substances, by posi-ly electrified surfaces, and attracted by negatively ctrified surfaces; and the oxygen follows the con-y order; or the oxygen being naturally possessed the negative energy, and the bases of the positive not remain in combination when either of them is ught into an electrical state opposite to its natural :. In the synthesis, on the contrary, the natural ergies or attractions come in equilibrium with each er; and when these are in a low state at common nperatures, a slow combination is effected; but when y are exalted by heat, a rapid union is the result, in other like cases with the production of fire.

A number of circumstances relating to the agencies the bases will be immediately stated, and will be und to offer confirmations to these general conclusions.

. *On the Properties and Nature of the Basis of Potash.*

After I had detected the bases of the fixed alkalies, ad considerable difficulty to preserve and confine m so as to examine their properties, and submit n to experiments; for, like the alkahests imagin-y the alchemists, they acted more or less upon al-st every body to which they were exposed.

The fluid substance amongst all those I have tried, which I find they have least effect, is recently dis-d naphtha. In this material, when excluded from air, they remain for many days without considera-changing, and their physical properties may be ly examined in the atmosphere when they are co-d by a thin film of it. The basis of potash at 60° renheit, the temperature in which I first examined appeared, as I have already mentioned, in small ules, possessing the metallic lustre, opacity and eral appearance of mercury; so that when a glo-e of mercury was placed near a globule of the pecu-substance, it was not possible to detect a difference the eye.

At 60° Fahrenheit it is, however, only imperfectly d, for it does readily run into a globule when its

shape is altered ; at 70° it becomes more fluid ; a
100° its fluidity is perfect, so that different glo
may be easily made to run into one. At 50° Fa
heit it becomes a soft and malleable solid, which
the lustre of polished silver ; and at about the free
point of water it becomes harder and brittle ;
when broken in fragments, exhibits a crystallized
ture, which, in the microscope, seems compose
beautiful facets of a perfect whiteness and high met
splendour.

To be converted into vapour, it requires a temper
ture approaching that of the red heat ; and when t
experiment is conducted under proper circumstance
it is found unaltered after distillation.

It is a perfect conductor of electricity. When
spark from the voltaic battery of an hundred of
inches is taken upon a large globule in the atmosphe
the light is green, and combustion takes place at the
point of contact only. When a small globule is
it is completely dissipated with explosion, accompa
by a most vivid flame, into alkaline fumes. It is a
excellent conductor of heat. Resembling the me
in all these sensible properties, it is, however, rema
ably different from any of them in specific gravity.
found that it rose to the surface of naphtha disti
from petroleum, and of which the specific gravity w
eight hundred and sixty-one, and it did not sink in d
ble distilled naphtha, the specific gravity of which
about seven hundred and seventy, that of water be
considered as one. The small quantities in which
is produced by the highest electrical powers, rende
it very difficult to determine this quality with mi
precision. I endeavored to gain approximations on
subject by comparing the weights of perfectly
globules of the basis of potash and mercury.
used the very delicate balance of the Royal Institu
which, when loaded with the quantities I emplo
and of which the mercury never exceeded ten g
is sensible, at least, to the $\frac{1}{2000}$ of a grain. T
the mean of four experiments, conducted with
care, its specific gravity at 62° Fahrenheit, is to
of mercury as 10 to 223, which gives a pro

f water nearly as 6 to 10; so that it is the luid body known. In its solid form it is a vier; but even in this state, when cooled to enheit, it swims in the double distilled naphtha.

hemical relations of the basis of potash are extraordinary than its physical ones.

already mentioned its alkalization and com- oxygen gas. It combines with oxygen slow- ithout flame at all temperatures that I have w that of its evaporation. But at this tempe- mbustion takes place, and the light is of a whiteness, and the heat intense. When heat- in a quantity of gas not sufficient for its com- version into potash, and at a temperature in- to its inflammation, 400° Fahrenheit for in- s tint changes to that of a red brown, and heat is withdrawn, all the oxygen is found to ed, and a solid is formed of a greyish colour, rtly consists of potash, and partly of the basis in a lower degree of oxygenation, and which potash by being exposed to water, or by being ted in fresh quantities of air. The substance of the basis of potash combined with an un- rtion of oxygen, may likewise be formed by y potash and its basis together under proper nces. The basis rapidly loses its metallic ; the two substances unite into a compound rown colour when fluid, and of a dark grey solid; and this compound soon absorbs its rtion of oxygen when exposed to the air, and converted into potash.

e same body is often formed in the analytical nts when the action of the electricity is in- l the potash much heated.

sis of potash, when introduced into oxymuri- gas, burns spontaneously with a bright red a white salt, proving to be muriat of potash,

a globule is heated in hydrogen at a degree point of vaporization, it seems to dissolve in globule diminishes in volume, and the gas *with alkaline* fumes and bright light, when

suffered to pass into the air ; but by cooling,
taneous detonating property is destroyed, an
is either wholly or principally deposited.

The action of the basis of potash on wate
to the atmosphere is connected with some bea
nomena. When it is thrown upon water, or
brought into contact with a drop of water a
temperature, it decomposes it with great vi
instantaneous explosion is produced with brill
and a solution of pure potash is the result.

In experiments of this kind, an appearanc
curs similar to that produced by the com
phosphorated hydrogen ; a white ring of sm
gradually extends as it rises into the air.

When water is made to act upon the basis
out of the contact of air, and preserved by n
glass tube under naphtha, the decomposition i
and there is much heat and noise but no lum
pearance ; and the gas evolved, when exami
mercurial or water pneumatic apparatus, is f
pure hydrogen.

When a globule of the basis of potash is p
on ice, it instantly burns with a bright flame, a
hole is made in the ice, which is found to con
lution of potash.

The theory of the action of the basis of po
water exposed to the atmosphere, though co
changes occur, is far from being obscure.
nomena seem to depend on the strong attracti
basis for oxygen and of the potash formed fo
The heat which arises from two causes, decon
and combination, is sufficiently intense to pro
inflammation. Water is a bad conductor of h
globule seems exposed to air ; a part of it, th
greatest reason to believe, is dissolved by th
nascent hydrogen ; and this substance being c
spontaneous inflammation, explodes and comm
the effect of combustion to any of the basis
be yet uncombined.

When a globule confined out of the contact
acted upon by water, the theory of decom

nple ; the heat produced is rapidly carried off, here is no ignition ; and a high temperature be- uisite for the solution of the basis in hydrogen, ıbination probably does not take place, or at least ıave a momentary existence only.

production of alkali in the decomposition of wa- ıe basis of potash, is demonstrated in a very and satisfactory manner by dropping a globule on moistened paper tinged with termeric. At nent that the globule comes into contact with er, it burns, and moves rapidly upon the paper, search of moisture, leaving behind it a deep brown trace, and acting upon the paper pre- s dry caustic potash.

ong is the attraction of the basis of potash for and so great the energy of its action upon wa- t it discovers and decomposes the small quanti- water contained in alcohol and ether, even when carefully purified.

ıer this decomposition is connected with an in- result. Potash is insoluble in this fluid ; and ıe basis of potash is thrown into it, oxygen is d to it, and hydrogen disengaged, and the alka- forms, renders the ether white and turbid.

h these inflammable compounds the energy of ı is proportionable to the quantity of water they and hydrogen and potash are the constant re-

basis of potash, when thrown into solutions of eral acids, inflames and burns on the surface. t is plunged by proper means beneath the sur- eloped in potash, surrounded by naphtha, it acts oxygen with the greatest intensity, and all its re such as may be explained from its strong af- r this substance. In sulphuric acid a white sa- stance, with a yellow coating, which is, proba- phat of potash surrounded by sulphur, and a ch has the smell of sulphurous acid, and which, , is a mixture of that substance with hydrogen formed. In nitrous acid, nitrous gas is disen- and nitrat of potash formed.

basis of potash readily combines with the sim-

thrown into water, this fluid is decomposed, potas formed, and the metals appear to be separated unalte ed.

The basis of potash combines with fusible meta and forms an alloy with it, which has a higher point fusion than the fusible metal.

The action of the basis of potash upon the inflamm ble oily compound bodies, confirms the other facts the strength of its attraction for oxygen.

On naphtha, colourless and recently distilled, as have already said, it has very little power of action but in naphtha that has been exposed to the air, it soo oxydates, and alkali is formed, which unites with t naphtha into a brown soap that collects round the glo ule.

On the concrete oils, (tallow, spermaceti, wax, for i stance) when heated it acts slowly, coaly matter is d posited, a little gas is evolved, and a soap is formed but in these cases it is necessary that a large quantity the oil be employed. On the fluid fixed oils it produce the same effects, but more slowly.

By heat likewise it rapidly decomposes the volati oils; alkali is formed, a small quantity of gas is evolv ed, and charcoal is deposited.

When the basis of potash is thrown into camphor i fusion, the camphor soon becomes blackened, no g is liberated in the process of decomposition, and a sapo naceous compound is formed; which seems to sho that camphor contains no more oxygen than the volatil oils.

The basis of potash readily reduces metallic oxyd when heated in contact with them. When a small quan tity of the oxyd of iron was heated with it, to a tem perature approaching its point of distillation, there wa a vivid action; alkali and grey metallic particles, whic dissolved with effervescence in muriatic acid, appeare

The oxyds of lead and the oxyds of tin were rev ved still more rapidly; and when the basis of potas was in excess, an alloy was formed with the reviv metal.

In consequence of this property the basis of potas readily decomposes flint glass, and green glass, w

gentle heat; alkali is immediately formed by oxygen from the oxyds, which dissolves the glass, and a new surface is soon exposed to the agent. At a red heat even the purest glass is altered by the basis of potash: the oxygen in the alkali of the glass seems to be divided between the two bases, the basis of potash and the alkaline basis in the glass and oxyds, in the first degree of oxygenation, are the result. When the basis of potash is heated in tubes made of plate glass, filled with vapour of naphtha, it first acts upon the small quantity of oxyds of cobalt and manganese in the interior surface of the glass, and a portion of alkali is formed. As the heat approaches to redness it begins to rise in vapour, and condense in the colder parts of the tube; but at the point, where the heat is strongest, a part of the vapour seems to penetrate the glass, rendering it a deep red-brown colour; and by repeatedly distilling and heating the substance in a close tube of this kind, it finally loses its metallic form, and a thick brown crust, which slowly decomposes water, and which combines with oxygen when exposed to air, forming alkali, lines the interior of the tube, and in many parts is found penetrating through its substance.

The basis of soda, is solid at common temperatures. It is white opaque, and when examined under a film of naphtha has the lustre and general appearance of silver. It is exceedingly malleable. Its specific gravity is less than that of water about 9 to 10, or. 9348 to 1.

The basis of soda has a much higher point of fusion than the basis of potash, its chemical phenomena are analogous to those produced by the basis of potash.

The proportions of the peculiar basis, and oxygen in potash and soda are, about six parts basis and one of oxygen in potash, and seven parts of basis and two of oxygen in soda.

PNEUMATIC CISTERN of Yale College.

An instrument has been for several years used in the laboratory of Yale College, for experiments in the large way, on the gases which water does not rapidly adsorb,

which has been found to be more convenient and complete than any other arrangement of apparatus for similar purposes. The only instrument of the kind which has ever been constructed, was manufactured in New-Haven. [*See Frontispiece.*] Being calculated for an extensive course of public lectures, delivered in a laboratory where there is plenty of room, its dimensions are larger than might be worth while in establishments on a smaller scale. Its form is that of a parallelopipedon, 7½ feet long, 3 feet wide, and 2 feet 2 inches deep, without allowing for the two inch pine plank of which this part of the instrument is constructed. The several planks and parts are connected by grooves and tongues, and bound together by iron rods, passing laterally through them, and terminating in screws furnished with nuts. The interior part is furnished with two shelves, [A.A.A.A.] each two feet six inches long, for sustaining air-jars and bell-glasses; the middle space between these is one foot eight inches wide, and forms a well [H] for immersing the bell-glasses; across this well is placed a sliding shelf, [G] with three inverted shallow tin funnels beneath it, corresponding with as many holes for receiving and transferring gases. Thus far, it is obvious that the instrument is only a very extensive pneumatic cistern, and has no superiority over those commonly in use, except from its affording ample space for a very important and interesting class of experiments, which are much more impressive and convincing to a large audience, when performed on a large scale. There are, however, a number of additional contrivances. Beneath each of the shelves are two inverted rectangular boxes, [*shewn by dotted lines at* I. I. *and under* A.A.A.A.] made of thin pine plank, dovetailed together at the angles, entirely open below, and attached to the inferior side of the shelves by tongues, grooves, and wood-screws. These boxes are twelve inches deep, of the capacity of about 12 gallons each, and occupy the whole space beneath the shelves except 7,5 inches at each end of the cistern, and nine inches between the bottom of the boxes and the bottom of the cistern. This latter space is reserved to give room for the action of three pair of hydrostatic bellows. [B.B.] They are made of leather, nailed to the bottom of the cistern.

distended by circular iron rings, and attached by nails to a thick circular plank which serves as a top, and which is moved up and down by an iron rod connected with an iron lever, [C.C.C.] which rests on a forked iron support, attached to the upper edge of the end of the cistern. The bellows are so placed, that nearly one half projects beneath the boxes, which we may call reservoirs ; the other part is beneath the open space which lies between the end of the reservoirs and the end of the cistern, and the rod of the bellows perforates the shelf immediately at the termination of the box and contiguous to it, but does not pass through the box, which must be air-tight. At the edge of that part of the bellows which projects beneath the reservoir, is a valve opening upward; in the centre of the bellows and on the bottom of the cistern, which is also the bottom of the bellows, is another valve opening upwards, covering an orifice which is connected with a duct, leading out, laterally, through the plank, edgewise, to the atmosphere. Into this duct is inserted a copper tube, [D.D.] consisting of two parts, one of which forms merely a portion of the duct, being driven into it so that it forms a perfectly tight connection ; the other part is soldered to this at right angles, and ascends in close contact with the outside of the cistern, till it rises two inches higher than its upper edge, and there it opens in an orifice somewhat dilated. Each of the four reservoirs may be considered as furnished with the apparatus of bellows, duct, valves, and tube ; although in the instrument to which this description refers, there are in fact but three bellows, &c. one reservoir being destitute of them. It remains to be remarked, that each reservoir is furnished with a stop-cock, which lies horizontally upon the shelf and partly imbedded in it, and passes into the reservoir by a short tube of copper, soldered at right angles with the cock.. The cocks of the two contiguous reservoirs are placed parallel to each other and to the sides of the cistern, and immediately contiguous to the partition which separates the reservoirs, and they are connected by a third stop-cock soldered to each of them, opening into both by proper orifices, and thus serving, *when occasion* requires, to connect the reservoirs, and *in fact, to convert* two into one. Through each of the

shelves, at the angles of the two reservoirs which are contiguous at once to that side of the cistern which may be regarded as its back part, and to the well, a hole is bored into the reservoir for the insertion of a copper tube [E.E.] for a blow-pipe. These tubes are so formed, that while one part is pressed firmly into the hole so as to be air-tight, another part, at right angles with the first, and bending in a pretty large curve, terminates in a trumpet-like orifice, adapted to the insertion of a cork. Immediately beneath these two orifices is a table, [F.] attached by hinges to the side of the cistern, to sustain a lamp for the blow-pipe; when not in use, it hangs by the side of the cistern, and is raised occasionally, as it is wanted.

To an intelligent chemist, it will be obvious from an attentive perusal of the description, that this instrument will afford all the following advantages.

1. It is an extensive pneumatic cistern, with every common convenience, on a large scale.

2. By the bellows and their appendages, common air may be thrown into the reservoirs, by which means the height of the water on the shelves may be increased at pleasure, when it is too low.

3. By permitting a portion of this air to escape, by opening one of the horizontal cocks, the height of the water on the shelves may be diminished at pleasure; thus we have means of graduating the height of the water precisely to our purpose without lading it out or in.

4. We have four capacious air-holders in the very place where the gases are produced, viz. in the pneumatic cistern; thus, four different kinds of gases may be stored away under water in a space otherwise useless. For instance, common air, for regulating the height of the water, or, for the blow-pipe, may be in one reservoir; oxygen gas in a second, hydrogen gas in a third, and olefiant gas in a fourth, and they may be thus reserved for future use.

5. The gases may be drawn off for use into bell-glasses, merely by bringing those bell-glasses, filled with water, over the horizontal cocks.

6. It is obvious that the four reservoirs are in fact four large gasometers; they want nothing to entitle them to this character, except a scale which a moderate share of ingenuity would easily adapt to them; the gases may be delivered into them at once by crooked tubes passing from the gas-bottles, and any gas contained in a bell-glass may be thrown into a reservoir, by a single stroke of the bellows. For this purpose a crooked tube connected with that which leads to the bellows and terminating in the well beneath an air jar, is all that is necessary. Or, by baring the arm, the gas may be thrown up by the hand, into the reservoirs, the jar being pushed down through the water.

7. It affords an excellent blow-pipe for common purposes and for the fine experiments with oxygen gas; and, by fitting to it Mr. Hare's very ingenious apparatus of the silver cylinder, it becomes the *compound blow-pipe*, for the invention and application of which he deserves so much credit. By the same contrivance water is formed with the greatest facility by burning the two gases as they come from their respective reservoirs, and issue at a common orifice, covering the flame with a receiver.

8. The inflammable gases being confined beneath the pressure of water, will issue at any orifices, where they are permitted, and thus all the ornamental as well as useful purposes to which the combustion of these gases is applied, may be exhibited; particularly, the gas from fossil coal may be made to burn in revolving jets, stars, and other fanciful and useful forms, merely by substituting for a blow-pipe tube, the apparatus proper for this exhibition.

All these purposes, this instrument has fully answered during several years; and it may be confidently recommended to lecturers on chemistry, and, on a smaller scale would be very valuable to a private chemist. A forcing pump might be substituted for the bellows, with a saving of the space which the bellows occupy, but it would be probably less convenient in practice.

This first idea of this instrument was suggested by Mr. Hare s compound blow-pipe. Being mentioned to that gentleman, the subject was prosecuted in common, and so far matured that it was afterwards executed by the writer, B. SILLIMAN.

MANUFACTURE of MINERAL WATERS.

The extensive utility of many of the natural mineral waters has been long established by the experience of mankind, and sanctioned by the opinions of the medical practitioners of every enlightened country— The accurate analysis of all the most important and most celebrated mineral waters has been accomplished by men competent to the task; and we are thus informed not only concerning the *nature*, but the [illegible] of the ingredients which they contain. They [illegible] either *fixed substances*, such as water can [illegible] [illegible] or *gases*, capable of being combined with the [illegible]. To both of these the mineral waters owe their medicinal powers, and to the latter alone, *and chiefly* [illegible] *carbonic acid*, their peculiar activity, briskness and pungency.

In the manufacture of artificial mineral waters, the [illegible] water is perfectly imitated, by the adding of [illegible] ingredients in the proper proportions: and [illegible] [illegible] peculiar and very powerful apparatus is [illegible] [illegible] forced in, till the waters acquire a degree of [illegible] and activity far surpassing any thing which [illegible] ever exhibit in nature. The impression [illegible] [illegible] by some, that a perfect imitation of the [illegible] mineral waters is impossible, is therefore equally [illegible] [illegible] to the decisions of good sense, as it is repugnant [illegible] experience; for in London, in Paris, and in many other great towns, artificial mineral waters are [illegible] [illegible]; and used to a great extent.

In the artificial waters, we always have it in our power to leave out noxious, or useless ingredients; to substitute others, and to vary the proportions at pleasure.

Every species of mineral waters whatever can [illegible] prepared by art, but the principal ones that have been attempted in this country, are the Ballstown, Soda, and the Seltzer waters.

BALLSTOWN WATER.

The Ballstown water is well known in the United States as a gentle cathartic,—an active diuretic,—[illegible]

medy against gravelly complaints,—a tonic to the stomach, and generally to the system;—not to mention its efficacy against rheumatic, and cutaneous complaints, when applied externally, as well as internally. It remains to be added, only, that the artificial Ballstown water is found by experience to produce the effects of the natural water; it is however more powerful, and therefore an equal quantity produces more marked effects.

SODA WATER.

The Soda water is not an exact imitation of *any* natural water, but has been directed by medical men as a remedy in a number of common and troublesome complaints. It is ordered in the pharmacopeias and dispensatories, and their prescriptions should be followed in this manufacture. It is a complete remedy against sourness of the stomach, commonly called heartburn, and in most cases of indigestion and weakness of the stomach it is very useful; gradually restoring the appetite, and with it the tone of the organ; it is a preventative of many of the diseases of the stomach and bowels, which proceed from acidity, and for the same reason it often removes or prevents the sick head-ache.

As a palliative, and even a remedy, in some cases of urinary calculi and gravelly complaints, it is preferable to the Ballstown water. It may prevent, arrest, retard, or remove the complaint according to circumstances.

The Soda water is also a very refreshing, and to most persons a very grateful drink, especially after heat and fatigue, and may be made a complete substitute for the beverages of which ardent spirits form a part.—With wine and sugar it is very grateful.

SELTZER WATER.

The Seltzer water has long been known, and is one of the most famous of the natural mineral waters of Europe. On account of its agreeable taste, and exhilirating effects, it is largely used at table, and as a beverage at all hours. It is a diuretic, and possesses considerable efficacy in nephritic and urinary complaints; it is

very useful against bilious and dyspeptic affections, and in many cases of cutaneous eruptions.

It possesses a peculiar power of allaying feverish irritation, and has done much service in slow hectic fevers; it mixes well with milk, and is thus used with advantage by hectic patients.—It is used also with sugar and wine.

The manufacture of mineral waters upon correct chemical principles was undertaken in New-Haven, Connecticut, about three years ago;' and during the last summer, a public establishment for this purpose was opened in the same town, under the direction of Professor Silliman.

An establishment of the same kind, and under the same direction, was effected in New-York in April of this year, (1809) by Noyes Darling & Co. Fountains of Ballstown, Soda, and Seltzer waters were opened in the bar of the Tontine Coffee House. The cisterns are placed in the cellar, and the waters are conveyed into the bar in block-tin tubes, which pass up into mahogany pillars, crowned with gilt urns, lettered with the names of the respective waters. The pillars, with their urns, stand a foot apart, and the middle one is raised above the others; silver stop-cocks inserted into the sides of the pillars, give the whole much neatness and richness of appearance.

The proprietors of this establishment intend, as we understand, to open fountains at the City Hotel, in the month of May, in a spacious room, fitted up and ornamented in a handsome style, and adapted to the accommodation of ladies as well as gentlemen.

The Ballstown and Seltzer waters are prepared according to an accurate analysis; and in order to give the Soda water its proper efficacy, it is made with the full proportion of Soda directed by the dispensatories.

The waters are bottled for exportation, in any quantity demanded.

Soda water has been made in New-York by Mr. Usher, for a year or more, and has had a good reputation and an extensive sale. It has been sold from a fountain, and in stone bottles. We understand that he is about to extend his establishment.

There have been, for some time, manufactories of mineral waters in the city of Philadelphia, and we are informed that these waters have been extensively used

be transmitted. Hence the importance of a fine white colour, when cloth is to receive bright dyes. It then reflects all the rays in abundance, and therefore any colour may be given, by covering it with a dye stuff which transmits only some particular rays.

If the colouring matters were merely spread over the surface of the fibres of cloth by the dyer, the colours produced might be very bright, but they could not be permanent; because the colouring matter would be very soon rubbed off; and would totally disappear whenever the cloth was washed, or even barely exposed to the weather. The colouring matter then, however perfect a colour it possesses, is of no value, unless it also adheres so firmly to the cloth that none of the substances usually applied to cloth, in order to clean it, &c. can displace it. Now this can only happen, when there is a strong *affinity* between the colouring matter and the cloth, and when they are actually combined together in consequence of that affinity.

Dyeing then is merely a chemical process, and consists in combining a certain colouring matter with fibres of cloth. This process can in no instance be performed, unless the dye stuff be first reduced to its integrant particles; for the attraction of aggregation between the particles of dye stuffs, is too great to be overcome by the affinity between them and the cloth, unless they could be brought within much smaller distances than is possible while they both remain in a solid form. It is necessary, therefore, previously to dissolve the colouring matter in some liquid or other, which has a weaker affinity for it than the cloth has. When the cloth is dipped into this solution, the colouring matter, reduced by this contrivance to a liquid state, is brought within the attracting distance; the cloth therefore acts upon it, and from its stronger affinity, takes it from the solvent and fixes it upon itself. By this contrivance too, the equality of the colour is in some measure secured, as every part of the cloth has an opportunity of attracting to itself the proper proportion of colouring particles.

The facility with which cloth imbibes a dye, depends upon two things; namely, the affinity between the cloth

nd the dye stuff, and the affinity between the dye-stuff and its solvent. It is directly as the former, and inversely as the latter. It is of importance to preserve a due proportion between these two affinities, as upon that proportion much of the accuracy of dying depends. If the affinity between the colouring matter and the cloth be too great, compared with the affinity between the colouring matter and the solvent, the cloth will take the dye too rapidly, and it will be scarcely possible to prevent its colour from being unequal. On the other hand, if the affinity between the colouring matter and the solvent be too great, compared with that between the colouring matter and the cloth, the cloth will either not take the colour at all, or it will take it very slowly and very faintly.

Wool has the strongest affinity for almost all colouring matters; silk the next strongest, cotton a considerably weaker affinity, and linen the weakest affinity of all. Therefore, in order to dye cotton or linen, the dye stuff should in many cases be dissolved in a substance for which it has a weaker affinity than for the solvent employed in the dyeing of wool or silk. Thus we may use oxyd of iron dissolved in sulphuric acid, in order to dye wool; but for cotton and linen, it is better to dissolve it in acetous acid.

Were it possible to procure a sufficient number of colouring matters, having a strong affinity for cloth, to answer all the purposes of dyeing, that art would be exceedingly simple and easy. But this is by no means the case; if we except indigo, the dyer is scarcely possessed of a dye stuff which yields of itself a good colour, sufficiently permanent to deserve the name of a dye.

This difficulty, which at first sight appears insurmountable, has been obviated by a very ingenious contrivance. Some substance is pitched upon, which has a strong affinity, both for the cloth and the colouring matter. This substance is previously combined with cloth, which is then dipped into the solution containing the dye stuff. The dye stuff combines with the intermediate substance, which, being firmly combined with the cloth, secures the permanence of the dye. Substances employed for this purpose are denominated mordants.

The most important part of dying, is undoubtedly the proper choice, and the proper application of mordants, as upon them, the permanency of almost every dye depends. Every thing which has been said respecting the application of colouring matters, applies equally to the application of mordants. They must previously be dissolved in some liquid, which has a weaker affinity for them than the cloth has to which they are to be applied: and the cloth must be dipped, or even steeped in the solution, in order to saturate itself with the mordant.

Almost the only substances used as mordants, are earths, metalic oxyds, tan, and oil.

Of earthy mordants, the most important, and most generally used, is alumine. It is used either in the state of common alum, in which it is combined with sulphuric acid, or in that of acetite of alumine.

Alum, when used as a mordant, is dissolved in water, and very frequently a quantity of tartar is dissolved along with it. Into this solution the cloth is put, and kept in it till it has absorbed as much alumine as is necessary. It is then taken out, and for the most part washed and dried. It is now a good deal heavier than it was before, owing to the alumine which has combined with it. The tartar serves two purposes; the potash which it contains combines with the sulphuric acid of the alum, and thus prevents that very corrosive substance from injuring the texture of the cloth, which otherwise might happen; the tartareous acid, on the other hand, combines with part of the alumine, and forms a tartrit of alumine, which is more easily decomposed by the cloth than alum.

Acetite of alumine has been but lately introduced into dying. This mordant is now prepared by pouring acetite of lead into a solution of alum; a double decomposition takes place, the sulphurious acid combines with the lead, and the compound precipitates in the form of an insoluble powder, while the alumine combines with the acetous acid, and remains dissolved in the liquid. This mordant is employed for cotton and linen, which have a weaker affinity than wool for alumine. It answers much better than alum; the cloth is more easily saturated with alumine, and takes, in consequence, both a richer and a more permanent colour.

Besides alumine, *lime* is sometimes used as a mordant. Cloth has a strong enough affinity for it; but, in general, it does not answer so well, as it does not give so good a colour. When used, it is either in the state of lime water, or of sulphat of lime dissolved in water.

Almost all the metalic oxyds have an affinity for cloth, but only two of them are extensively used as mordants, namely, the oxyds of tin, and of iron.

The oxyd of tin was first introduced into dyeing by KUSTER, a German chemist, who brought the secret to London in 1543. This period forms an era in the history of dyeing. The oxyd of tin has enabled the moderns greatly to surpass the ancients in the finess of their colours; by means of it alone, *scarlet*, the brightest of all colours is produced.

Tin, as PROUST has proved, is capable of two degrees of oxydation. The first oxyd is composed of 0.70 parts of tin, 0.30 of oxygen; the second, or white oxyd, of 0.60 parts of tin, and 0.40 of oxygen. The first oxyd absorbs oxygen with very great facility, even from the air, and is rapidly converted into white oxyd. This fact makes it certain, that it is the white oxyd of tin alone, which is the real mordant; even if the other oxyd were applied to cloth, as it probably often is, it must soon be converted into white oxyd, by absorbing oxygen from the atmosphere.

Tin is used as a mordant in three states; dissolved in nitro muriatic acid, in acetous acid, and in a mixture of sulphuric and muriatic acids. Nitro muriat of tin is the common mordant used by dyers. They prepare it by dissolving tin in diluted nitric acid, to which a certain proportion of muriat of soda, or of ammonia is added. Part of the nitric acid decomposes these salts, combines with their base, and sets the muriatic acid at liberty. They prepared it at first, with nitric acid alone, but that mode was very defective, because the nitric acid very readily converts tin to white oxyd, and then is incapable of dissolving it. The consequence of which was, the precipitation of the whole of the tin. To remedy this defect, common salt, or sal ammoniac, was very soon added; muriatic acid having the property of *dissolving* white oxyd of tin very readily. A conside-

rable saving of nitric acid might be obtained by employing as much sulphuric acid as is just sufficient to saturate the base of the common salt, or sal ammoniac employed.

When the nitro-muriat of tin is to be used as a mordant, it is dissolved in a large quantity of water, and the cloth is dipped in the solution, and allowed to remain till sufficiently saturated. It is then taken out, and washed and dried. Tartar is usually dissolved in the water along with the nitro muriat. The consequence of this is a double decomposition, the nitro-muriatic acid combines with the potash of the tartar, while the tartarous acid dissolves the oxyd of tin. When tartar is used, therefore, in any considerable quantity, the mordant is not a nitro muriat but a tartrit of tin.

Iron, like tin, is capable of two degrees of oxydation; but the green oxyd absorbs oxygen so readily from the atmosphere, that it is very soon converted into the red oxyd. It is only this last oxyd which is really used as a mordant in dyeing. The green oxyd is indeed, sometimes applied to cloth; but it very soon absorbs oxygen, and is converted into the red oxyd.—This oxyd has a very strong affinity for all kinds of cloth. The permanency of the iron spots on linen and cotton is a sufficient proof of this. As a mordant, it is used in two states; in that of sulphat of iron, and acetite of iron. The first is commonly used for wool. The salt is dissolved in water, and the cloth dipped in it. It may be used also for cotton, but in most cases acetite of iron is preferred. It is prepared by dissolving iron, or its oxyd, in vinegar, sour beer, &c. and the longer it is kept, the more it is preferred. The reason is, that this mordant succeeds best when the iron is in the state of red oxyd. It would be better then to oxydate the iron, or convert it into rust, before using it; which might easily be done, by keeping it for some time in a moist place, and sprinkling it occasionally with water.

Tan has a very strong affinity for cloth, and for several colouring matters; it is therefore very frequently employed as a mordant. An infusion of *nut-galls*, or of *sumach*, or any other substance containing tan, is

made in water, and the cloth is dipped in this infusion, and allowed to remain till it has absorbed a sufficient quantity of tan. Silk is capable of absorbing a very great proportion of tan, and by that means acquires a great increase of weight. Manufacturers sometimes employ this method of increasing the weight of silk.

Tan is often employed also, along with other mordants, in order to produce a compound mordant. Oil is also used for the same purpose, in the dyeing of cotton and linen. The mordants with which tan most frequently is combined, are alumine, and oxyd of iron.

Besides these mordants, there are several other substances frequently used as auxiliaries, either to facilitate the combination of the mordant with the cloth, or to alter the shade of colour; the chief of these are *tartar, acetite of lead, common salt, sal ammoniac, sulphat of acetite of copper*, &c.

Mordants not only render the dye permanent, but have also considerable influence on the colour produced. The same colouring matter produces very different dyes, according as the mordant is changed. Suppose, for instance, that the colouring matter be cochineal; if we use the aluminous mordant, the cloth will acquire a crimson colour; but the oxyd of iron produces with it a black.

In dyeing then, it is not only necessary to procure a mordant which has a sufficiently strong affinity for the colouring matter and the cloth, and a colouring matter which possesses the wished for colour in perfection, but we must procure a mordant and a colouring matter of such a nature, that when *combined together*, they shall possess the wished for colour in perfection. It is evident too, that a great variety of colours may be produced with a single dye stuff, provided we can change the mordant sufficiently.

The colouring matter with which the cloth is dyed, does not cover every portion of its surface; its particles attach themselves to the cloth at certain distances from each other; for the cloth may be dyed different shades of the same colour, lighter or darker, merely by varying the quantity of colouring matter. With *a small quantity*, the shade is light; and it becomes

deeper as the quantity increases; now this would be impossible, if the dye stuff covered the whole of the cloth.

That the particles of colouring matter, even when the shade is deep, are at some distance, is evident from this well known fact, that cloth may be dyed two colours at the same time. All those colours to which the dyers give the name of *compound*, are in fact two different colours applied to the cloth at once. Thus cloth gets a green colour, by being dyed first *blue* and then *yellow*.

The colours denominated by dyers *simple*, because they are the foundation of all their other processes, are four; namely, first, *blue*; second, *yellow*; third, *red*; fourth, *black*. To these they usually add a fifth, under the name of *root* or *brown* colour.

Of Dyeing Blue.

The only colouring matters employed in dying blue, are *woad* and *indigo*.

Woad is a plant cultivated in this kingdom, and even growing wild in some parts of England.

Indigo is a blue powder, extracted from a species of plants which is cultivated for that purpose in the East and West Indies. These plants contain a peculiar green pollen, which in that state is soluble in water. This pollen has a strong affinity for oxygen, which it attracts greedily from the atmosphere; in consequence of which it assumes a *blue* colour, and becomes insoluble in water.

Indigo has a very strong affinity for wool, silk, cotton and linen. Every kind of cloth, therefore, may be dyed with it, without the assistance of any mordant whatever. The colour thus induced is very permanent; because the indigo is already saturated with oxygen, and because it is not liable to be decomposed by those substances, to the action of which the cloth is exposed. But it can only be applied to cloth in a state of solution; and the only solvent known being sulphuric acid, it would seem at first sight, that the sulphuric acid solution is the only state in which indigo can be employed as a dye.

The *sulphat of indigo* is indeed often used to dye wool and silk blue; but it can scarcely be applied to cotton and linen, because the affinity of these substances for indigo is not great enough to enable them readily to decompose the sulphat. The colour given by sulphat of indigo is exceedingly beautiful; it is known by the name of *Saxon blue*.

Of Dyeing Yellow.

The principal colouring matters for dyeing yellow are weld, fustic, and quercitron bark.

Weld is a plant which grows in this country.

Fustic is the wood of a large tree which grows in the West Indies.

Quercitron is a tree growing naturally in North America, the bark of which contains colouring matter.

The yellow dyed by means of fustic is more permanent, but not so beautiful as that given by weld, or quercitron. As it is permanent, and not much injured by acids, it is often used in dyeing compound colours, where a yellow is required. The mordant is alumine. When the mordant is oxyd of iron, fustic dyes a good permanent drab colour.

Weld and quercitron bark, yield nearly the same kind of colour; but as the bark yields colouring matter in much greater abundance, it is much more convenient, and upon the whole cheaper than weld. It is probable, therefore, that it will gradually supercede the use of that plant. The method of using each of these dye stuffs is nearly the same.

Of Dyeing Red.

The colouring matters employed for dyeing red, are *kermes*, *cochineal*, *archil*, *madder*, *carthamus*, and *Brazil-wood*.

Kermes is a species of insect, affording a red colour by solution in water; but it is not so beautiful as cochineal, which is likewise an insect found in America.—The decoction of cochineal is a very beautiful crimson colour. Alum brightens the colour of the decoction, and occasions a crimson precipitate. Muriat of tin gives a copious fine red precipitate.

Archil is a paste formed of a species of lichen pounded, and kept moist for some time with stale urine.

Madder is the root of a well known plant.

Carthamus is the flower of a plant cultivated in Spain and the Levant. It contains two colouring matters: a yellow, which is soluble in water, and a red, insoluble in water, but soluble in alkaline carbonats. The red colouring matter of carthamus, extracted by carbonat of soder, and precipitated by lemon juice, constitutes the *rouge* used by ladies as a paint. It is afterwards ground with a certain quantity of talc. The fineness of the talc, and the proportion of it mixed with the carthamus, occasion the difference between the cheaper and dearer kinds of rouge.

Brazil wood, is the wood of a tree growing in America and the West Indies.—Its decoction is a fine red colour.

None of the red colouring matters have so strong an affinity for cloth as to produce a permanent red, without the assistance of mordants. The mordants employed are alumine, and oxyd of tin; oil, and tan, in certain processes, are also used; and tartar and muriat of soder, are frequently called in as auxiliaries.

Wool may be dyed *scarlet*, the most splendid of all colours, by first boiling it in a solution of murio sulphat of tin, then dying it pale yellow with quercitron bark, and afterwards crimson, with cochineal; for scarlet is a compound colour consisting of *crimson* mixed with a little *yellow*.

Silk is usually dyed red with cochineal, or carthamus, and sometimes with Brazil wood. Kermes does not answer for silk; madder is scarcely ever used for that purpose, because it does not yield a colour bright enough. Archil is employed to give silk a bloom; but it is scarcely used by itself, unless when the colour wanted is *lilac*.

Silk may be dyed crimson by steeping it in a solution of alum, and then dying it in the usual way in a cochineal bath.

Silk cannot be dyed a full scarlet; but a colour approaching to scarlet may be given it, by first impregna-

ing the stuff with murio sulphat of tin, and afterwards dyeing it in a bath, composed of four parts of cochineal, and four parts of quercitron bark. To give the colour more body, both the mordant and the dye may be repeated. A colour approaching scarlet may be also given to silk, by first dying it crimson, then dying it with carthamus, and lastly, yellow without heat. Cotton and linnen are dyed red with madder. The process was borrowed from the East. Hence, the colour is often called Adrianople, or Turkey red. The cloth is first impregnated with oil, then with galls, and lastly with alum. It is then boiled for an hour in a decoction of madder, which is commonly mixed with a quantity of blood. After the cloth is dyed, it is plunged into a soda ley, in order to brighten the colour. The red given by this process, is very permanent, and when properly conducted, it is exceedingly beautiful. The whole difficulty consists in the application of the mordant, which is by far the most complicated employed in the whole art of dying.

Of Dyeing Black.

The substances employed to give a black colour to cloth are, red oxyd of iron, and tan. These two substances have a strong affinity for each other; and when combined, assume a deep black colour, not liable to be destroyed by the action of air or light.

Logwood is usually employed as an auxiliary, because it communicates lustre, and adds considerably to the fullness of the black. It is the wood of a tree which is a native of several of the West India islands, and of that part of Mexico which surrounds the Bay of Honduras. It yields its colouring matter to water. The decoction is at first a fine red, bordering on violet; but if left to itself, it gradually assumes a black colour. Acids give it a deep red colour; alkalies a deep violet, inclining to brown; sulphat of iron renders it as black as ink, and occasions a precipitate of the same colour.

Wool is dyed black by the following process: It is boiled for two hours in a decoction of nut-galls, and afterwards kept for two hours more in a bath composed of logwood and sulphat of iron, kept during the whole

time at a scalding heat, but not boiled. During the operation it must be frequently exposed to the air; because the green oxyd of iron, of which the sulphat is composed, must be converted into red oxyd by absorbing oxygen, before the cloth can acquire a proper colour. The common proportions are five parts of galls, five of sulphat of iron, and thirty of logwood, for every hundred of cloth. A little acetite of copper, is commonly added to the sulphat of iron, because it is thought to improve the colour.

Silk is dyed nearly in the same manner. It is capable of combining with a great deal of tan; the quantity given is varied at the pleasure of the artist, by allowing the silk to remain a longer or shorter time in the decoction.

Of Dying Compound Colours.

Compound colours are produced by mixing together two simple ones; or, which is the same thing, by dying cloth first one simple colour, and then another.—These colours vary to infinity, according to the proportions of the ingredients employed. They may be arranged under the following classes:

Mixtures of 1. Blue and yellow; 2. Blue and red; 3. Yellow and red; 4. Black, and other colours.

Mixtures of blue and yellow. This forms green, which is distinguised by dyers into a variety of shades, according to the depth of the shade, or the prevalence of either of the component parts. Thus we have *sea-green*, *grass-green*, *pea-green*, &c.

Wool, silk, and linen, are usually dyed green, by giving them first a blue colour, and afterwards dying them yellow; because, when the yellow is first given, several inconveniencies follow: the yellow partly separates again in the blue vat, and communicates a green colour to it, and thus renders it useless for every other purpose, except dying green. Any of the usual processes for dying blue and yellow may be followed, taking care to proportion the depth of the shades to that of the green required. When sulphat of indigo is employed, it is usual to mix all the ingredients together, and to dye the cloth at once; this produces what is known by the name of Saxon, or English green.

Mixtures of blue and red. These form different shades of *violet*, *purple*, and *lilac*. Wool is generally first dyed blue, and afterwards scarlet, in the usual manner. By means of cochineal mixed with sulphate of indigo, the process may be performed at once. Silk is first dyed crimson, by means of cochineal, and then dipped into the indigo vat. Cotton and linen are first dyed blue, then galled, and soaked in a decoction of logwood; but a more permanent colour is given by means of oxyd of iron.

Mixtures of yellow and red. This produces *orange*. When blue is combined with red and yellow on cloth, the resulting colour is *olive*. Wool may be dyed orange, by first dyeing it scarlet, and then yellow. When it is dyed first with madder, the result is *cinnamon colour*.

Silk is dyed orange by means of carthamus; a cinnamon colour by logwood, Brazil-wood, and fustic mixed together.

Cotton and linen receive a cinnamon colour by means of weld and madder; and an olive colour, by being passed through a blue, yellow, and then a madder bath.

Mixtures of black with other colours. These constitute *greys*, *drabs*, and *browns*. If cloth be previously combined with brown oxyd of iron, and afterwards dyed yellow with quercitron bark, the result will be a *drab* of different shades, according to the proportion of mordant employed. When the proportion is small, the colour inclines to olive or yellow; on the contrary, the drab may be deepened or saddened, as the dyers term it, by mixing a little sumach with the bark.

TANNING.

TANNING is the art of converting the raw skins of animals into *Leather*. *Skins* are the general term for the shins of calves, seals, hogs, dogs, &c. As the methods of tanning in general use have been found tedious and expensive in their operation, various schemes, at different times, have been suggested to shorten the process and lessen the expense.

Much light has been thrown by modern chemists upon the theory of tanning. M. Seguin, in France, has particularly distinguished himself by his researches on this subject, and much improved the art in his country.

A few years since W. Lesmond obtained a patent for practising Seguin's method in England. He obtained the tanning principle by digesting oak bark, or other proper materials, in cold water, in an apparatus nearly similar to that used in the saltpetre works:— That is to say, the water which has remained upon the powdered bark a certain time, in one vessel, is drawn off by a cock, and poured upon fresh tan—this is again to be drawn off, and poured upon other fresh tan; and in this way the process is to be continued to the fifth vessel. The liquor is then highly coloured, and marks from six to eight degrees upon the hydrometer for salts. This he calls the tanning lixivium. The criterion for ascertaining its strength, is the quantity of the solution of gelatine which a given quantity of it will precipitate. Isinglass is used for this purpose, being intirely composed of gelatine. And here it may be observed, that this is the mode of ascertaining the quantity of tanning principle in any vegetable substance, and consequently how far they may be used as a substitute for oak bark.

The hides, after being prepared in the usual way, are immersed for some hours in a weak tanning lixivium of only one or two degrees; to obtain which, the latter portions of the infusions are set apart, or else some of that which has been partly exhausted by use in tanning. The hides are then to be put into a stronger lixivium, where, in a few days, they will be brought to the same degre of saturation with the liquor in which they are immersed. The strength of the liquor will by this means be considerably diminished, and must therefore be renewed. When the hides are by this means completely saturated, that is to say, perfectly tanned, they are to be removed, and slowly dried in the shade.

The length of time necessary to tan leather completely, according to the old process, is certainly a

ry great inconvenience; and there is no doubt but that it may be much shortened by following the new method. It has been found, however, that the leather so tanned has not been so durable as that which has been formed by a slower process.

The public is much indebted to Mr. Davy, professor of chemistry in the Royal Institution, for the attention which he has paid to the subject. From his excellent paper "on the constituent parts of astringent vegetables," in the Philosophical Transactions, we present the reader with the following extract.—

"The different qualities of leather made with the same kind of skin, seem to depend very much upon the different quantities of extractive matter it contains. The leather obtained by means of infusions of galls, is generally found harder, and more liable to crack, than the leather obtained from the infusion of barks; and in all cases it contains a much larger proportion of tannin, and a smaller proportion of extractive matter.

"When skin is very slowly tanned in weak solutions of the barks, or of catechu, it combines with a considerable proportion of extractive matter; and in these cases, though the increase of weight of the skin is comparatively small, yet it is rendered perfectly insoluble in water, and is found soft, and at the same time strong. The saturated astringent infusions of barks contain much less extractive matter in proportion to the tannin, than the weak infusions; and when skin is quickly tanned in them, common experience shews that it produces leather less durable than the leather slowly formed.

"Besides, in the case of quick tanning by means of infusions of barks, a quantity of vegetable extractive matter is lost to the manufacturer, which might have been made to enter into the composition of his leather. These observations shew, that there is some foundation for the vulgar opinion of workmen, concerning what is technically called the *feeding* of leather in the slow method of tanning; and though the processes of the art may in some cases be protracted for an unnecessary length of time, yet, in general, they appear to have arrived, in consequence of repeated practical experi-

ments, at a degree of perfection which cannot [illegible] exceeded by means of any elucidations of [illegible] that have as yet been known."

It was first suspected by Sir Joseph Banks, [illegible] afterwards confirmed by the experiments of P[illegible] Davy, that a substance called *catechu* or *terra* [illegible] brought from the East Indies, contained a vast [illegible] of tannin; so much so, that it far excels every known substance in this respect. One pound of [illegible] contains as much tannin as eight or ten pounds [illegible] mon oak bark, and would consequently tan pro[illegible] tionately as much more leather. It is an extrac[illegible] from the wood of a species of mimosa, by d[illegible] and subsequent evaporation.

Oak bark being a very expensive article in [illegible] cess of tanning, various substances have been p[illegible] as substitutes for it. All the parts of vegetable[illegible] are of an astringent nature, contain tannin, wh[illegible] be known by their giving precipitates with [illegible] insoluble in water, and will answer this purpose[illegible] leaves, branches, fruit, flowers, of a vast nu[illegible] plants; every part of the oak, as the leaves an[illegible] oak saw-dust, and the barks of almost all trees, [illegible] more or less tannin.

CURRYING.

Currying is the art of dressing cow-hides, [illegible] skins, &c. The principal object in this process [illegible] soften and supple cow and calf skins, which are employed in making upper-leathers and quarters [illegible] the covers of saddles, coaches, &c. As soon [illegible] skins are brought from the tanner's yard, the [illegible] first soaks them for some time in common water; he takes them out, stretches them on a smooth horse, scrapes off with a paring-knife all the sup[illegible] flesh, and immerses them again. They are [illegible] on a wet hurdle, and trampled with the heels [illegible] become soft and pliant, when they are steeped [illegible] oil, and afterwards spread out on large tables, [illegible] ends tightly secured. Then, by means of a [illegible]

(an instrument consisting of a thick piece of wood, the lower side of which is full of furrows, or teeth, crossing each other), the currier folds, squares, and moves the skins in various directions, to render them supple. This operation is properly called *currying*; and, with a few immaterial exceptions, is that now generally followed.

After the skins are thus dressed, they are coloured, black, white, red, green, &c. which process is performed either on the *flesh* or *grain* side; that on the former, by skinners, and that on the *grain* or *hair* side, by curriers: these, when a skin is to be made white, rub it with chalk, or white-lead, and afterwards with pumice-stone. But, when a black colour is wanted, the skin must be first oiled and dried, then passed over a puff, dipped in water impregnated with iron, when it is immersed in another water prepared with soot, vinegar, and gum-arabic. Thus it gradually acquires a deep dye, and the operations are repeated till it becomes of a shining black. The grain and wrinkles, which contribute to the pliancy of calves and cows leather, are made by the reiterated folds given to the skin in every direction, and by the great care taken to scrape off every excrescence and hard place on the grain, or colour-side.

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